Technological Innovation and Policy Responses in Health Care

Technological Innovation and Policy Responses in Health Care

A dissertation presented

by

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to

the Department of Health Policy

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

Health Policy

Harvard University

Cambridge, Massachusetts

April 2013

Dissertation Advisor: Prof. Robert J. Blendon Michael David Botta

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Abstract

This dissertation consists of three papers, two quantitative and one mixed-methods. Paper 1 uses cross-sectional and logistic regression analyses of survey data to assess Americans' opinion on the use of cost effectiveness research (CER) in government health coverage decisions, and to examine the factors predicting approval or disapproval of specific decisions. I use vignettes drawn from real international decisions to assess opinions. I find that opposition to a CER agency is widespread, with partisan affiliations playing a significant role. In general, Republicans are more likely to oppose a government agency playing a role in cost effectiveness determinations. With regards to specific examples, Americans hold even greater opposition, with no significant differences by political affiliations.

Paper 2 evaluates the hospital- and state-level factors influencing hospital adoption of electronic health records (EHRs), attempting to identify levers subject to influence by policy makers in the ongoing effort to drive increased adoption. This project employs multi-level poisson regression to examine cross-state variation in the relationship between hospital function adoption and hospital/state level characteristics. I find that a multitude of factors influence hospital EHR adoption, with several subject to influence by policy makers. In particular, prospective financial incentives at the state level to hospitals struggling to break even financially have a noted effect in increasing adoption.

Paper 3 uses a mixed-methods approach to answer the question of whether hospitals view the requirements of the EHR meaningful use incentive program as a floor, above which further development continues, or as a ceiling on their adoption efforts. I draw three key findings from this research: first, the requirements serve as either a floor or a ceiling, depending on the abilities of the facility implementing

EHRs. Second, the increasing focus on meeting the requirements risks missing the forest of health care system change through the trees of meeting discrete requirements. Without further development on the technology needed for managing population health, the American health care system lacks the infrastructure for successful health reform. Third, while the meaningful use incentive program has accelerated the development and implementation of some functions, it has also slowed development of other important functions.

Dedication

To my grandmother, Emerita Hernández-Pérez, for showing me how one person's life touches so many others. A toast, to my grandmother -- the richest woman in town.

Acknowledgements

For as long as I can remember, my favorite author has been Kurt Vonnegut. When I was in high school, I went to hear him give a reading, and at some point, he stopped to give a piece of advice: "I urge you to please notice when you are happy," he said, "and exclaim or murmur or think at some point, 'If this isn't nice, I don't know what is.'" So when you read this, just know that, at Harvard, I've been happy. And if this hasn't been nice, well then I don't know what is. I've got quite a few people to thank for my ongoing happiness, and this seems like a good place to start.

This dissertation wouldn't exist without the guidance of my committee, the support of my friends, and the love of my family and girlfriend. I offer my sincerest gratitude to my advisor, Dr. Robert Blendon, who has supported and guided me as I've pursued my interests, while always reminding me to keep thinking about issues that matter. Dr. David Cutler has been a mentor and a consistent inspiration. The limits of human productivity don't seem to apply to him, given the amount of attention he is able to pay to his advisees while simultaneously publishing the definitive studies of record on every issue of note in health policy. Dr. Ashish Jha graciously allowed me the opportunity to work with him and his stellar team, including Sidney Le and Jie Zheng, who regularly amaze me with their statistical brilliance. Drs. Blendon, Cutler, and Jha both guided me and challenged me. Their willingness to mentor me has helped make this dissertation a far, far better product than it would have been in their absence, and me a far, far better scholar than I would have been without their continued presence in my development.

The Program in Health Policy has been an incredible resource from the moment I first began toying with the idea of coming to Harvard. Joan Curhan helped steer me in the right direction (that direction of course being the Political Analysis track with Professor Blendon). Deborah Whitney and Ayres Heller have followed admirably in Joan's footsteps. Their dedication to all of us in the PhD program has made this experience better than I ever could have imagined when I first showed up at

their offices in December of 2007, which feels, as I write this, to have been roughly 647 years ago. Give or take six months.

To the Agency for Healthcare Research and Quality for funding me through a traineeship. You've given me a chance to be inspired by the transformative potential of effective, accurate research.

Professors Bob Mnookin and Bob Bordone of the Harvard Program on Negotiation: thank you for taking a chance on me and inspiring me so thoroughly that you haven't been able to get rid of me for the past three years.

There are many others whom I need to acknowledge, and I could write enough copy singing their praises to cost the Earth several rainforests, but for now the abridged versions will have to suffice:

Chris Elms has been, at various times over the past fourteen years, a roommate, a tour guide, a travel companion, a confidant, a classmate, a teammate, a cross-country-drive-partner, and one half of the only New York Jets divisional playoffs victory party happening in Boston, Massachusetts. At all times over the past fourteen years, he has been my best friend.

Beth Wikler has been a constant source of friendship, laughter, joy, and the kind of mutual commiseration that can only come from sitting side-by-side, writing SAS code for problem sets, in the CGIS basement at the wee hours of the morning.

Zirui Song (one of Boston Magazine's Top Doctors of 2009!) is a brilliant scholar, a tireless advocate for his patients, and a deadly three-point shooter. He is also a selfless, loyal friend who has helped me navigate grad school from our first day of Math Camp.

Louis Epstein and Joey Cotruvo somehow convinced me to move to Boston, largely by sugarcoating the deleterious effects of New England Winters. Thanks for that, guys.

My Brazilian Jiu-Jitsu teammates at Gracie Barra Back Bay have become a second family. Alex Costa, my instructor, is a role model in his humility and quiet strength. Also, he has introduced me to every good Brazilian BBQ joint in Massachusetts.

To my uncle, Robert, and my sister, Diane -- your perseverance is an inspiration. You walk like you've got oil wells pumping in your living rooms.

To my grandfather, who continues to show me that there is pure joy in learning and bettering one's self. Next up: smartphones.

My parents, to whom I owe everything. They never fail to lend an ear when I'm in need of a welcoming listener, or provide a word of encouragement when I start to envision the weight of the world on my shoulders. For sacrificing for the sake of their children, for inspiring me to aim high and achieve big things, and for teaching me to trust myself, even when all men doubt me (but to make allowance for their doubting too!), I thank them.

To Chelsea -- phenomenal woman, that's you. Plus, the conclusion of my Vonnegut story! When I went to Kurt Vonnegut's reading back in my Regis days, the book he was promoting was called Timequake. I don't particularly recommend it unless you're looking to really delve into the proverbial b-sides of the Vonnegut catalog, but I'll single out one highlight, in the form of a quote:

> Many people need desperately to receive this message: 'I feel and think much as you do, care about many of the things you care about, although most people do not care about them. You are not alone.'

The moment I met you, I knew this statement was true, and that I'd received the message.

As I close the door on my Harvard career with this dissertation, I thank Pedro Arrupe, S.J. for the notion that I should strive to be a man for others, and Robert Frost for reminding me that I have promises to keep, and miles to go before I sleep.

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Paper 1: Cost Effectiveness Research and United States Public Opinion

Introduction

Health systems in the developed world face numerous challenges. Chief among them for several years has been the inability to effectively control health care spending growth. Across the OECD, nations have seen their health care spending growing by upwards of seven percent each year until a more recent recession-induced slowdown[1]. In the United States, despite slow economic growth due to the global recession, health care spending still looks to grow by nearly 6 percent annually over the next eight years, outpacing GDP growth by over one percent per year[2].

As nations seek to stem the tide of rising health care spending, many have turned to cost effectiveness analysis as a way to reduce spending on low value interventions. Nations such as the UK, Italy, Germany, and Australia now judge the clinical benefits and costs of new treatments relative to the current standards of care, and set explicit thresholds for the additional value per dollar required to justify government health care systems paying for or providing new treatments. In the United States, however, the idea of implementing cost effectiveness research into coverage decisions at the government level has yet to be pursued.

Comparative effectiveness research (CER) – research measuring the incremental value of new treatments over existing treatments without regard to cost – has only just recently been appropriated significant funding and a government foothold in the form of a public-private partnership now known as the Patient-Centered Outcomes Research Institute (PCORI). PCORI is banned from incorporating cost assessments into their evaluations, but has still become the subject of intense political debate.

Considerable political controversy over the proper role of cost or comparative effectiveness in Medicare and Medicaid decision-making, and arguments that PCORI starts the United States down the slippery slope toward cost effectiveness evaluations and explicit rationing by cost have made the field politically sensitive[3]. From the time that President Obama sought to allocate $1.1 billion for similar

research through the 2009 American Recovery and Reinvestment Act, opponents have strenuously objected to the research with highly charged rhetoric[4]. As recently as July of 2012, House Republicans offered up proposed budgets which would strip all funding from PCORI and shutter the institute entirely[5]. Furthermore, the pharmaceutical industry has fought an expanded role for comparative effectiveness research with extensive lobbying[6]. Regardless of consistent rebuttals from the Obama administration and PCORI officials that no such factors will be taken into account, opponents continue to drive opposition by tying the research soon to be funded by PCORI to the types of cost effectiveness-driven decisions made abroad by public HTA bodies like NICE and IQWiG in the UK and Germany, respectively[7,8]. Yet despite the ongoing political turmoil over comparative effectiveness, very little research has to-date focused on Americans' attitudes towards a government role for cost effectiveness as a tool for use in government decision-making.

In the years to come, the idea of instituting a larger role for cost effectiveness research will almost certainly be offered in the national debate, as financial pressures on the health care system and the nation as a whole continue to compound. To inform the anticipated cost effectiveness debate, this study analyzes the extent and structure of public opinion on a government cost effectiveness agency, and specific coverage decisions driven by cost effectiveness research, studied through the use of vignettes derived from real-world decisions in nations with active cost effectiveness agencies. This study also analyzes public opinion on specific areas of potential cost-effectiveness-driven decision-making to identify which types of analyses are likely to generate the most support or opposition, and from whom.

Study Aims and Hypotheses:

This study examines whether a government cost effectiveness agency has widespread appeal, or whether public opinion on the issue is divided along similar lines as other health policy issues. Further, it looks at the specific types of decisions likely to be made by a government cost effectiveness agency to see if those decisions are more or less popular than an agency itself. This study is designed to inform

those active in health policymaking and health services research on the extent of support or opposition and the degree to which partisanship and a variety of sociodemographic factors predict patterns of public opinion on the issue.

Five primary research questions drive this study:

1. What is the level of support among the general public for a government cost effectiveness agency?
2. What political and sociodemographic factors predict support for a government cost effectiveness agency?
3. Are specific types of likely coverage decisions made by a future government cost effectiveness agency more popular than an agency itself?
4. What political and sociodemographic factors predict support for specific types of CER-driven coverage decisions?
5. Do Republicans and Democrats have different patterns of support for a government cost effectiveness agency and specific CER-driven coverage decisions?

Methods:

Data Source

The data are derived from a four-country survey by the Harvard School of Public Health and the Alliance for Aging Research. The survey was supported by a grant to the Alliance for Aging Research from Bayer AG. Bayer was not involved in the design of the survey or the analysis of the findings.

Fieldwork was conducted via telephone (landline and cell) with nationally representative random samples of adults age 18 and older by SSRS/ICR, an independent research company. In the United States (the focus of this research), a total of 1017 interviews were conducted between June 28 – July 24, 2011. The margin of error is +/- 3.9%.

Many of the questions were asked of split samples, where one half was asked about prescription drugs, the other half about medical or surgical treatments. Because vignette and outcome variable responses showed no statistically significant differences between asking about medical or surgical treatments, the data for the two forms were combined for clarity of presentation and to increase statistical power.

The Institutional Review Board at the Harvard School of Public Health ruled that this study is not human subjects research (Protocol #20104-101, December 16, 2010).

Outcome Measures

The outcome measure for research questions one and two is "support for a government cost-effectiveness agency." (The variable is coded as support/favor = 1; oppose=0.) Support is defined as occurring when respondents said they would favor such an agency with decision-making authority for either prescription drugs or medical/surgical treatments. The questions were asked slightly differently to each half of the sample, with assignments to the questions made randomly. There were no significant

differences in the patterns of responses to the two forms of the question, so they have been combined for increased statistical power. (See Appendix C for complete question wordings).

The outcome measures for research questions three through five are support for each of four CER-driven decision vignettes. (Each vignette is coded as support/favor=1; oppose=0.) Vignettes were written on the basis of real CER-driven decisions made by the CER/Health Technology Assessment (HTA) bodies in three nations: the United Kingdom, Germany, and Italy. Information on each vignette was sourced from scholarly and mass media articles written about the decisions, and vetted by representatives of the relevant CER/HTA bodies in each nation. The vignettes were designed to present a fair depiction of how the debate over each decision was framed in each nation at the time, in order to give as accurate a depiction as possible of how the debate could expect to be framed in the United States for similar decisions.

Support for a vignette is defined as occurring when respondents replied that they favored the decision made by the CER body in the vignette presented to them. The vignettes were asked of split samples, with each respondent randomly assigned to two of the four vignettes.

The vignettes are as follows:

Vignette 1 Summary: Access for a new drug to treat a serious, debilitating disease was limited to a subpopulation most likely to see significant health benefits because the government decided it was not worth the cost to provide to the entire population of those with the disease.

Vignette 1 Analog: (UK) NICE decision on availability of Beta Interferon for treatment of Multiple Sclerosis[9,10].

Vignette 2 Summary: Two drugs are available to treat a debilitating condition in the elderly, with one being substantially (100x) more expensive than the other. The more expensive drug is indicated for the

condition, while the less expensive is used off-label. The CER body decided to cap reimbursement at a level which would only pay for the less-expensive of the two drugs.

Vignette 2 Analog: (Italy) AIFA decision on Avastin (off-label) and Lucentis (indicated) for treatment of Wet AMD[11–13].

Vignette 3 Summary: A decision-making body decided not to provide an expensive cancer drug which could add, on average, about six months of life to a patient with an advanced form of cancer.

Vignette *3 Analog: (UK) NICE decision on availability of Avastin for use in treating Bowel Cancer*[14].

Vignette 4 Summary: A decision-making body decided not to pay for the use of an expensive imaging technology in diagnosing certain types of cancers, arguing there was not enough evidence of increased efficacy to justify the increased cost.

Vignette 4 Analog: (Germany) IQWiG decision on payment for PET scans for use outside the indication of diagnosing head and neck tumors[15].

(Complete vignette wordings are included in Appendix A).

Independent Variables

The independent variables in my analyses are as follows:

a. Political Party – Democrat, Independent, Republican
b. Total family income before taxes
c. Education
d. Age – 18-29, 30-49, 50-64, 65+
e. Race – White (Non-Hispanic), Hispanic, Black (Non-Hispanic)
f. Gender – Male, Female
g. Trust in Government to Make Health Care Decisions – Yes, No
h. Satisfaction with US Health Care System – Very Satisfied, Fairly Satisfied, Neither Satisfied Nor Dissatisfied, Fairly Dissatisfied, Very Dissatisfied
i. Exposure of self or an immediate family member to a serious illness – Yes, No
j. Long-Term Use of Prescription Medication – Yes, No

(Additional information on item wordings for these independent variables is included in Appendix C.)

Analysis plan

A post-stratification weighting design was used to weight all collected interviews to represent the country's adult population. Weighting targets included telephone status (landline, cell) and various individual demographics: race/ethnicity, age, gender, education, and region. To address item non-response, I used listwise deletion where only the units that have observations for each of the measures under consideration are included. For this reason, sample sizes varied for each analysis.

To begin, I examined unadjusted cross-tabulated relationships, identifying significant differences among subgroups by way of chi-square tests of significance. To evaluate the fit of regression models, I used t-tests for each dichotomous variable, and F-tests for joint significance of related variables with more than two categories. All tests of significance were conducted at the conventional 95% confidence level ($P<.05$).

To answer research questions one and three, I examine the weighted results of the measure of support for a government cost-effectiveness agency and for each of the four vignettes presented. For research question two, I examine cross-tabulated statistics on the measure of support for a government cost-effectiveness agency, tabulating by the independent variables described above. I also estimate a logistic regression of support for a government cost-effectiveness agency on the independent variables listed above. To answer the research question, I interpret the odds ratios from this regression. To answer research question four and five I estimate and interpret logistic regressions for the four vignettes on the independent variables described above.

Results

The weighted distribution of sociodemographic and partisan identifications are roughly proportionate to the estimated distribution in the country as a whole (sample demographics are included in Appendix D).

Support for a Government Cost Effectiveness Agency

A majority of the overall population opposes a government cost effectiveness agency. About 56 percent of respondents would oppose such an agency (Table 1.1). Democrats are about evenly split on the issue (49.8% supporting) while a significantly smaller percentage of Republicans would support a government cost effectiveness agency (26.9%). There were no significant differences in the rate of support by gender, race, income, serious illness experience, or education, but younger respondents aged 29 or below were significantly more likely to support an agency (64.7%) than respondents aged 65 or above (31.2%). There were no significant differences in agency support among various levels of satisfaction with the US health care system, but those who trust the government to make decisions on health care issues are significantly more likely (64.9%) to support a government CER agency than those who do not trust the government on matters of health care (32.6%). Using chi-square tests at the .05 level, all differences across groups shown here are significant.

Table 1.1: Survey Crosstabs on Support for Government CER Agency and CER-Driven Decision Vignettes

	CER Agency		Vig 1		Vig 2		Vig 3		Vig 4		Any Vignette	
	% Support	95% CI	% Support	95% CI	% Support	95% CI	% Support	95% CI	% Support	95% CI	% Support	95% CI
Total	44.10%	[40.2-48.1]	28.70%	[23.6-34.4]	26.80%	[22.2-31.9]	38.70%	[33.5-44.2]	35.00%	[29.7-40.7]	50.10%	[46.2-53.9]
Gender												
Male	47.30%	[41.5-53.2]	35.30%	[27.5-43.9]	32.60%	[25.6-40.5]	44.80%	[36.8-53.0]	40.00%	[31.9-48.6]	58.00%	[52.2-63.5]
Female	41.10%	[35.9-46.6]	22.80%	[16.6-30.6]	20.90%	[15.6-27.6]	32.40%	[26.1-39.4]	30.70%	[24.0-38.3]	42.70%	[37.6-48.0]
Race/Ethnicity												
White (Non-Hispanic)	38.00%	[33.5-42.7]	21.90%	[16.9-27.9]	29.60%	[24.2-35.8]	36.70%	[30.9-42.9]	33.40%	[27.4-40.0]	48.00%	[43.6-52.5]
Black (Non-Hispanic)	42.40%	[30.7-55.0]	31.30%	[17.0-50.5]	13.40%	[6.6-25.4]	44.70%	[29.0-61.6]	36.90%	[21.4-55.6]	51.70%	[39.3-63.8]
Hispanic	66.50%	[54.1-77.0]	48.20%	[32.1-64.6]	18.20%	[9.3-32.5]	39.20%	[23.9-57.1]	39.40%	[24.5-56.5]	57.10%	[45.0-68.4]
Age												
Age 18-29	64.70%	[54.1-74.1]	43.50%	[29.3-58.9]	34.60%	[22.0-49.8]	46.90%	[32.7-61.6]	42.20%	[28.1-57.7]	61.50%	[51.0-71.0]
Age 30-49	43.30%	[36.4-50.4]	31.30%	[22.9-41.0]	21.20%	[14.5-30.0]	29.10%	[20.9-39.0]	32.00%	[23.5-41.9]	46.30%	[39.5-53.3]
Age 50-64	38.00%	[31.7-44.7]	19.40%	[13.2-27.5]	24.60%	[18.2-32.5]	40.20%	[31.9-49.0]	30.90%	[22.7-40.4]	47.00%	[40.6-53.6]
Age 65+	31.20%	[25.1-38.0]	16.40%	[10.3-25.2]	30.80%	[22.4-40.7]	45.90%	[36.2-55.9]	37.00%	[28.1-47.0]	48.90%	[42.2-55.6]
Party Identification												
Democrat	49.80%	[42.6-57.1]	29.70%	[20.8-40.4]	22.60%	[15.7-31.5]	35.70%	[26.8-45.7]	37.60%	[27.9-48.4]	49.90%	[42.8-57.0]
Republican	26.90%	[19.6-35.6]	26.20%	[16.3-39.3]	35.30%	[25.1-47.0]	41.50%	[30.8-53.1]	29.70%	[19.6-42.2]	51.30%	[43.3-59.2]
Independent	48.60%	[41.8-55.6]	28.80%	[20.6-38.5]	24.70%	[17.2-34.0]	40.20%	[31.1-50.1]	36.90%	[28.1-46.5]	51.30%	[44.4-58.1]
Total Household Income												
Less than $10,000	55.20%	[37.1-72.1]	5.70%	[1.1-24.2]	20.50%	[7.6-44.7]	42.90%	[21.3-67.5]	34.30%	[14.6-61.5]	42.90%	[26.5-61.1]
$10,000-$15,000	56.70%	[37.9-73.8]	44.70%	[19.4-73.0]	36.10%	[15.1-64.3]	29.10%	[10.8-58.2]	59.80%	[32.7-82.0]	57.20%	[38.7-73.9]
$15,000-$20,000	51.30%	[34.9-67.5]	20.70%	[6.6-49.1]	30.60%	[16.1-50.2]	30.40%	[15.9-50.3]	29.00%	[9.9-60.5]	47.30%	[32.0-63.1]
$20,000-$25,000	47.10%	[27.7-67.4]	45.30%	[19.8-73.6]	22.30%	[6.8-53.2]	26.30%	[10.8-51.4]	51.40%	[25.2-76.9]	63.70%	[43.6-80.0]
$25,000-$30,000	34.80%	[19.0-54.9]	21.10%	[5.9-53.4]	25.50%	[11.3-47.9]	50.20%	[28.3-72.1]	29.50%	[8.8-64.4]	56.20%	[37.2-73.5]
$30,000-$35,000	37.60%	[18.9-61.0]	65.80%	[39.0-85.3]	17.10%	[5.8-41.0]	24.30%	[8.4-52.9]	16.50%	[4.9-43.2]	54.60%	[33.4-74.2]
$35,000-$40,000	44.20%	[25.3-64.9]	43.40%	[20.3-69.9]	18.20%	[5.4-46.3]	36.80%	[13.4-68.8]	56.80%	[31.1-79.3]	68.60%	[49.4-83.0]
$40,000-$50,000	45.40%	[30.6-61.0]	39.80%	[19.4-64.4]	28.60%	[14.7-48.1]	27.30%	[13.7-47.1]	24.50%	[10.3-48.0]	47.10%	[32.6-62.1]
$50,000-$75,000	46.60%	[36.6-56.8]	21.10%	[12.3-33.9]	32.10%	[19.4-48.2]	54.60%	[39.2-69.1]	30.70%	[19.9-44.1]	53.90%	[43.9-63.6]
$75,000-$100,000	34.10%	[24.2-45.6]	16.50%	[8.1-30.9]	28.40%	[16.3-44.6]	22.50%	[11.6-39.0]	24.60%	[13.7-40.2]	38.10%	[28.1-49.2]
$100,000 and over	42.40%	[34.0-51.1]	30.80%	[20.5-43.3]	27.00%	[17.9-38.7]	51.10%	[39.2-62.8]	37.20%	[26.2-49.6]	53.80%	[45.4-61.9]
Highest Level of Education Completed												
Less Than High School	62.80%	[47.7-75.7]	25.40%	[11.1-48.3]	14.10%	[4.9-34.3]	29.90%	[14.4-51.9]	40.20%	[23.0-60.2]	41.30%	[28.1-55.9]
High School Graduate	42.50%	[34.8-50.6]	32.20%	[22.0-44.5]	17.00%	[10.4-26.5]	33.10%	[24.3-43.3]	29.40%	[20.0-41.1]	44.50%	[37.0-52.3]
Technical School	20.10%	[7.3-44.5]	8.90%	[1.1-45.7]	22.60%	[6.6-54.5]	18.50%	[5.5-47.2]	21.70%	[3.2-70.0]	30.70%	[14.1-54.5]
Some College	42.10%	[34.7-49.9]	30.20%	[20.8-41.6]	32.20%	[23.4-42.6]	38.20%	[28.6-48.9]	43.40%	[32.7-54.7]	57.30%	[50.0-64.4]
Graduated College	41.40%	[33.6-49.7]	23.20%	[15.1-34.0]	35.00%	[24.2-47.7]	54.10%	[42.1-65.7]	25.50%	[17.6-35.5]	49.00%	[41.0-57.0]
Graduate School	46.70%	[38.4-55.2]	32.80%	[22.2-45.5]	40.30%	[28.9-52.8]	47.60%	[35.5-60.0]	39.80%	[29.2-51.5]	61.70%	[53.8-69.1]
Trust in Government to Make Health Care Decisions												
Do Not Trust	32.60%	[28.1-37.5]	19.70%	[14.4-26.3]	28.60%	[23.0-35.0]	39.20%	[33.1-45.8]	30.90%	[24.6-38.1]	46.20%	[41.5-51.0]
Trust	64.90%	[57.9-71.3]	43.10%	[33.5-53.2]	24.10%	[16.5-33.7]	38.00%	[28.3-48.8]	43.50%	[33.9-53.7]	57.90%	[50.8-64.7]
Satisfied With US Health Care System												
Very Satisfied	46.10%	[35.6-56.9]	34.80%	[21.5-51.0]	10.80%	[5.2-21.1]	43.60%	[29.1-59.4]	36.60%	[23.7-51.9]	51.00%	[40.7-61.2]
Fairly Satisfied	44.80%	[36.8-53.1]	25.80%	[16.3-38.2]	27.50%	[18.5-38.9]	43.60%	[33.0-54.8]	40.90%	[29.8-53.1]	52.70%	[44.8-60.6]
Neither Satisfied Nor Dissatisfied	57.20%	[42.2-71.0]	32.60%	[16.5-54.1]	37.10%	[19.4-59.1]	64.20%	[42.6-81.3]	32.50%	[16.0-54.7]	61.10%	[46.2-74.1]
Fairly Dissatisfied	46.30%	[38.3-54.5]	33.90%	[23.8-45.7]	35.10%	[24.8-47.0]	34.70%	[25.1-45.7]	32.30%	[22.7-43.6]	51.50%	[43.5-59.4]
Very Dissatisfied	37.10%	[30.2-44.6]	21.60%	[13.7-32.4]	25.10%	[18.3-33.4]	32.00%	[23.8-41.4]	29.40%	[20.5-40.3]	44.00%	[37.1-51.1]
Self or Family Member Experienced Serious Illness in Past 12 Months												
No	44.90%	[40.0-50.0]	28.90%	[22.5-36.3]	28.10%	[22.4-34.5]	41.40%	[34.9-48.3]	39.40%	[32.5-46.8]	52.90%	[48.0-57.7]
Yes	43.10%	[36.6-49.8]	28.30%	[20.5-37.7]	24.30%	[17.3-33.0]	33.50%	[25.5-42.7]	27.00%	[19.7-35.9]	45.60%	[39.3-52.1]

Factors Predicting Support for a Government Cost Effectiveness Agency

Many of the differences seen in the crosstab analysis above persist in a regression of support for a government cost effectiveness agency on the covariates (Table 1.2). Democrats and Independents are significantly more likely to support a government cost effectiveness agency than Republicans. Individuals at the lower end of the age distribution (18-29) are more likely than those at the higher end (65 plus) to support a CER agency. Individuals who trust the government to make health care decisions are, not surprisingly, also more likely to support a government CER agency than their counterparts who do not trust the government in this arena. There are no significant differences by illness status, income, race, education, gender, or satisfaction with the health care system.

Table 1.2. Logistic Regression Results Evaluating Variables Predictive of Support for a Government Cost Effectiveness Agency

	Full Model	Reduced Model
Party Identification		
Democrat	1	1
Republican	0.401** [0.229,0.700]	0.448** [0.261,0.769]
Independent	1.959 [0.602,1.530]	1.146 [0.734,1.788]
Serious Illness	1.062 [0.732,1.540]	0.992 [0.683,1.441]
Trust Government	2.878*** [1.929,4.296]	3.110*** [2.089,4.628]
Age		
Age 18-29	1	1
Age 30-49	0.401** [0.226,0.710]	0.389*** [0.223,0.679]
Age 50-64	0.381*** [0.215,0.673]	0.353*** [0.202,0.620]
Age 65+	0.280*** [0.154,0.510]	0.263*** [0.146,0.473]
Education	0.952 [0.849,1.067]	--
Gender	0.770 [0.534,1.110]	--
Race/Ethnicity		
White	1	--
Black	0.716 [0.391,1.309]	--
Hispanic	1.860+ [0.952,3.634]	--
Observations	926	926
Pseudo R^2	0.13	0.114

Odds Ratios; 95% confidence intervals in brackets

Source: Data from 2011 Survey Conducted by Harvard School of Public Health

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Support for CER-Driven Coverage Decisions

None of the vignettes see majority support, with two of the vignettes (vignettes one and two) gaining significantly less support than a government CER agency at the 95% confidence level. Support for vignette four is significantly lower than support for a government CER agency at the 90% confidence level.

Vignette 1

Overall, about 29 percent of respondents supported the decision to limit drug availability to just the subpopulation(s) most likely to gain a benefit. Women (22.8%) were significantly less likely than men (35.3%) to support the decision. About twenty-two percent of whites favored the decision, as compared to about forty-eight percent of Hispanics. Younger adults were more likely to support the decision than older adults, with about forty-four percent of adults aged 18-29 in support as compared to about nineteen percent of adults aged 50-64 and about sixteen percent of adults over the age of sixty-five. Those who trust the government to make health care decisions were significantly more likely to agree with the first decision, with about 43 percent supporting as compared to about twenty percent in the non-trusting group. There were no significant differences among income, education, and satisfaction levels, or by serious illness experience. Furthermore, differences among partisan affiliations were not significant, with Democrats, Republicans, and Independents all seeing between twenty-five and thirty percent of their ranks supporting the decision. Using chi-square tests at the .05 level, all differences across groups shown here are significant.

Vignette 2

About twenty-seven percent of respondents supported the decision to provide only the off-label drug for treating this condition in the elderly. Across the reference categories, education level stands out as the only area where statistically significant differences persist – those with graduate degrees are

significantly more likely to support the vignette than those with high school graduations or below, with over 40 percent supporting among the former and about 17 percent supporting among the latter category. There were no other significant differences among any of the included reference categories.

Vignette 3

Overall, about thirty-nine percent of respondents supported the decision not to provide a drug which would add about six months to an end-stage cancer patient's life at a very high cost. Those who experienced a serious illness were less likely to support the decision, with about thirty-three percent supporting as compared to about forty-one percent support among those who had not experienced a significant illness. There were no other significant differences among any of the included reference categories.

Vignette 4

About thirty-five percent of respondents supported the decision to restrict availability of an expensive imaging technology to only specific types of cancers. Those who experienced a serious illness were significantly less likely to support the decision, with about twenty-seven percent support as compared to nearly forty percent support among those who had not experienced a significant illness. There were no other significant differences among any of the included reference categories.

Any Vignette

Overall, about half of respondents supported the decision made in at least one of the vignettes. Men were significantly more likely than women to have supported at least one vignette, with about fifty- eight percent of men supporting at least one as compared to about forty-three percent of women. Those who experienced a serious illness were significantly less likely to support any vignette, with about forty-six percent supporting any as compared to about fifty-three percent supporting any among those

who had not experienced a significant illness. Those respondents with graduate degrees were significantly more likely to have supported at least one vignette, with about sixty-two percent having supported at least one, as compared to about forty-five percent of high-school graduates having supported at least one decision.

Factors Predicting Support for CER-Driven Coverage Decisions

Many of the differences detailed above persist in regressions of support for each vignette on the covariates. Logistic regressions of support for CER-driven coverage decisions on the independent variables described above allow me to better analyze which sociodemographic and partisan groups are significantly more or less supportive of these decisions than others, controlling for the other factors in the analysis.

Vignette 1

A logistic regression of support for Vignette 1 on the covariates shows several significant differences. Females are less than half as likely as males to support the vignette, while Hispanics are over three times as likely as Whites to support. Americans over 50 and those over 65 are each about 40% as likely as those between the ages of 18 and 29 to support, while those who trust the government to make health care decisions are over 2.5 times as likely to support the vignette.

Vignette 2

A logistic regression of support for Vignette 2 on the covariates shows that few significant differences persist. Only the relationship between education and support persists, with each increasing level of education about 1.3 times as likely to support the vignette. The remaining factors, including gender, race/ethnicity, party identification, self-interest (illness status), and age do not show significant differences in support for a government providing only an off-label drug to treat a serious condition in the elderly.

Vignette 3

Logistic regression results of support for Vignette 3 on the covariates show similar results to Vignette 2. Few significant differences persist overall. Each increasing level of education was about 1.2 times as likely to support the vignette, while women were between one-half and two-thirds as likely as men to support the vignette. No other variables showed significant differences in support.

Vignette 4

Vignette 4, which describes a scenario in which a more expensive imaging technology for use in diagnosing cancers is limited to specific types of cancers, has several significant differences that hold in a logistic regression. Women are about .6 times as likely as men to support this decision, and those who trust the government to make health care decisions are about 1.7 times as likely to support it as those who do not. Respondents who experienced a serious illness (personally or within their immediate family) in the past year – a variable representing self-interest – were about 60% as likely to support the decision, with this relationship holding at the $p<0.1$ level.

Any Vignette

For the analysis, I also conducted a regression of support for any vignette on the covariates. Looking across all the vignettes, women were significantly less likely to have supported any vignette than men, with women about half as likely to have supported any vignette. Hispanics were about 1.7 times as likely to have supported a vignette as Whites, and those who trust the government in making health care decisions were about 1.5 times as likely to have supported any vignette as those who do not. Furthermore, each increasing level of education was about 1.2 times as likely to have supported a vignette. No significant differences persisted on the basis of age or party ID across responses to the vignettes when looking at the response patterns as a whole.

Table 1.3. Logistic Regression Results Evaluating Variables Predictive of Support for Vignette 1		
	Full Model	Reduced Model
Gender	0.458** [0.259,0.810]	0.486* [0.277,0.851]
Race/Ethnicity		
White	1	1
Black	1.246 [0.476,3.260]	1.254 [0.547,2.874]
Hispanic	3.404** [1.488,7.784]	2.925** [1.312,6.519]
Party Identification		
Democrat	1	--
Republican	1.380 [0.495,3.851]	--
Independent	0.729 [0.313,1.696]	--
Serious Illness	1.376 [0.771,2.458]	1.329 [0.751,2.350]
Trust in Government	2.961*** [1.600,5.480]	2.656*** [1.519,4.646]
Age		
Age 18-29	1	1
Age 30-49	0.771 [0.342,1.738]	0.752 [0.333,1.695]
Age 50-64	0.374* [0.155,0.904]	0.392* [0.167,0.919]
Age 65+	0.407+ [0.159,1.038]	0.412+ [0.166,1.024]
Education	1.104 [0.914,1.333]	--
Observations	455	455
Pseudo R-squared	0.125	0.116
Odds Ratios; 95% confidence intervals in brackets		
Source: Data from 2011 Survey Conducted by Harvard School of Public Health		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Table 1.4. Logistic Regression Results Evaluating Variables Predictive of Support for Vignette 2	
	Full Model
Gender	0.597+ [0.352,1.011]
Race/Ethnicity	
White	1
Black	0.430+ [0.167,1.106]
Hispanic	0.593 [0.239,1.472]
Party Identification	
Democrat	1
Republican	1.190 [0.551,2.569]
Independent	0.850 [0.900,1.722]
Serious Illness	0.901 [0.520,1.561]
Trust Government	0.900 [0.470,1.722]
Age	
Age 18-29	1
Age 30-49	0.595 [0.260,1.363]
Age 50-64	0.778 [0.351,1.726]
Age 65+	1.135 [0.490,2.628]
Education	1.330** [1.115,1.587]
Observations	471
Pseudo R-squared	0.077
Odds Ratios; 95% confidence intervals in brackets	
Source: Data from 2011 Survey Conducted by Harvard School of Public Health	
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001	

Table 1.5. Logistic Regression Results Evaluating Variables Predictive of Support for Vignette 3		
	Full Model	Reduced Model
Gender	0.562* [0.355,0.889]	0.569* [0.364,0.890]
Race/Ethnicity		
White	1	1
Black	2.038* [0.902,4.609]	1.684 [0.799,3.548]
Hispanic	1.899 [0.804,4.486]	1.171 [0.543,2.527]
Party Identification		
Democrat	1	--
Republican	1.109 [0.564,2.182]	--
Independent	1.362 [0.720,2.577]	--
Serious Illness	0.846 [0.512,1.396]	0.781 [0.485,1.256]
Trust Government	0.911 [0.517,1.606]	--
Age		
Age 18-29	1	--
Age 30-49	0.446* [0.210,0.946]	--
Age 50-64	0.976 [0.497,1.916]	--
Age 65+	1.347 [0.662,2.738]	--
Education	1.238** [1.058,1.448]	1.194** [1.033,1.381]
Observations	489	489
Pseudo R-squared	0.064	0.033
Odds Ratios; 95% confidence intervals in brackets		
Source: Data from 2011 Survey Conducted by Harvard School of Public Health		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Table 1.6. Logistic Regression Results Evaluating Variables Predictive of Support for Vignette 4		
	Full Model	Reduced Model
Gender	0.590+ [0.346,1.005]	0.608+ [0.367,1.006]
Race/Ethnicity		
White	1	
Black	0.860 [0.314,2.359]	
Hispanic	1.160 [0.493,2.727]	
Party Identification		
Democrat	1	
Republican	0.672 [0.298,1.517]	
Independent	0.886 [0.455,1.723]	
Serious Illness	0.591+ [0.342,1.020]	0.600+ [0.353,1.022]
Trust Government	1.518 [0.854,2.698]	1.701* [1.017,2.843]
Age		
Age 18-29	1	
Age 30-49	0.628 [0.289,1.362]	
Age 50-64	0.583 [0.263,1.291]	
Age 65+	0.942 [0.422,2.104]	
Education	1.018 [0.864,1.199]	
Observations	457	457
Pseudo R-squared	0.044	0.033
Odds Ratios; 95% confidence intervals in brackets		
Source: Data from 2011 Survey Conducted by Harvard School of Public Health		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Table 1.7. Logistic Regression Results Evaluating Variables Predictive of Support for any Vignette		
	Full Model	Reduced Model
Supported any one of the vignettes		
Gender	0.542*** [0.388,0.756]	0.551*** [0.396,0.767]
Race/Ethnicity		
White	1	1
Black	1.182 [0.638,2.190]	1.098 [0.616,1.956]
Hispanic	1.801* [1.017,3.190]	1.729+ [0.994,3.005]
Party Identification		
Democrat	1	--
Republican	1.076 [0.650,1.781]	--
Independent	1.001 [0.642,1.560]	--
Serious Illness	0.884 [0.631,1.239]	0.877 [0.626,1.231]
Trust Government	1.503* [1.022,2.212]	1.528* [1.060,2.201]
Age		
Age 18-29	1	--
Age 30-49	0.567* [0.334,0.962]	--
Age 50-64	0.690 [0.403,1.181]	--
Age 65+	0.878 [0.505,1.527]	--
Education	1.198*** [1.080,1.329]	1.186** [1.071,1.314]
Observations	956	956
Pseudo R-squared	0.051	0.042
Odds Ratios; 95% confidence intervals in brackets		
Source: Data from 2011 Survey Conducted by Harvard School of Public Health		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Discussion

In the modern American political system, for a policy option to successfully navigate the path from a bill to a law requires widespread public appeal. This study shows that, despite the benefits of cost effectiveness research, many of which seem intuitive within the health policy community, it engenders widespread opposition. Instituting a government cost effectiveness agency to make coverage decisions does not secure majority support, and is particularly unpopular among Republicans and several subpopulations, including those with the greatest self-interest in maintaining broad access to health care services – those with histories of serious illness.

Among some subpopulations the results are not as dire for proponents of cost effectiveness research. About two-thirds of each of Hispanics, young adults, and those who trust the government to make health care decisions support the idea of a government cost effectiveness agency at present. With the shifting demographics in the United States, this suggests that support for a role for cost effectiveness research in government health care decision-making may well increase over time. Not only is trust in government at historic lows, but young adults and Hispanics represent an increasing share of the electorate.

Unfortunately for proponents, policies with diffuse benefits and concentrated costs are among the most difficult to advance in the American political system[16]. The results demonstrate that, as the politics of self-interest would suggest, those with histories of serious illness are most likely to oppose any such effort, and would have natural political allies on this issue in the form of Republicans against any government expansion.

While my initial hypothesis maintained that a government CER agency would be less popular than individual decisions reached on the basis of cost effectiveness analysis, this turned out not to be the case. It was true that the individual vignettes did not meet with the type of partisan divide that was

evident in the responses to the question on a government CER agency, but each vignette engendered widespread opposition from individuals of all political persuasions. In all but one case (Vignette 1), those individuals who professed to trust the government to make health care decisions did not agree with the theoretical decisions made on the basis of scientific evidence. Given that cost effectiveness analysis depends on scientific research, the validity of which can be difficult to understand fully without significant education, one initial hypothesis was that those with higher levels of education would be more likely to support the findings summarized in the vignettes. This hypothesis is given some confirmation in the analysis, as those respondents who had completed graduate school were significantly more likely to have supported any of the vignettes than those with a high school education. The role of self-interest in health care decision-making was again clear when evaluating responses to any of the vignettes, as those who had experienced a serious illness were significantly more likely to oppose any of the vignettes than those who had not had such an experience.

Limitations

This study has limitations that future research could address. First, abstract policy-making decisions remain difficult for many in the public to understand. While I have attempted to limit the degree of abstraction present in the questions through the use of vignettes, they still require that the respondent answer without knowing the specifics of the disease state or data used in support of the decision.

Second, although respondents were told that cost and comparative effectiveness decisions may have a role in limiting future health care costs, individuals might have responded differently if told that the use of this research could eventually lower their taxes or health insurance premiums in the future, should they turn out to effectively save money. This was not discussed based on the belief that any savings realized as a result of cost effectiveness research would be more likely to see use in preventing

future rate increases rather than directly lowering present-day taxes or premiums. This hypothesis, which in my opinion is the most likely outcome, is nevertheless by no means the certain outcome.

Finally, the survey was fielded in the midst of debate over increasing the debt limit to avoid potential government default --- a time of extraordinarily low trust in government. This environment may have produced a more powerful bias against government's role in health care that would not be present in a future political environment.

Lessons for Policymakers and Advocates

Despite the aforementioned limitations, there are several important lessons for policymakers and advocates to draw from this work. First, the partisan divide evident in many issues of health care policy is also evident when discussing a government cost effectiveness agency, which would make its implementation extremely difficult at present. Those who suspect that such an agency would be less controversial once the types of decisions it would be making were clearer to the American public are likely to be disappointed, as individual decisions remain less popular than the agency itself.

Cost effectiveness research does not appear to have a natural constituency, but it does have many natural enemies, both politically with Republicans and in the population at large. Those with serious illnesses would be likely to mobilize against such an agency, with disease advocacy groups likely to find support from their membership in this quest. Policymakers in favor of implementing a role for cost effectiveness analysis in government health-care decision making may see more success in waiting for a demographic shift in the United States. As younger adults increase in age and as more Hispanics enter the electorate, the results of this study suggest support could increase. Furthermore, trust in government is likely to rebound somewhat over time, which may also reduce resistance.

The overarching lesson from my analyses is that although the idea of a government cost effectiveness agency is unpopular, the types of decisions such an agency would make – once thought to

be relatively non-controversial given their reliance on data and evidence – would engender even greater opposition from the public. At present, were a government cost effectiveness agency to be instituted, it would have little hope of limiting access to treatments, even treatments which rigorous analyses suggest are of little value, without widespread opposition. In particular, those with the strongest self-interest in maintaining access to as wide a range of treatment options as possible would be expected to mobilize to oppose any efforts to limit access to any treatment.

Despite the opposition at present, the political history of health care debates in America suggest that a willing coalition could eventually overcome public opposition. There is potential to change this situation if leadership groups in government and the private sector show willingness and determination to adopt CER-driven policies in health care decision-making. That stand would face public opposition in the short term, but successful implementation would likely reduce opposition over time. Growing health care spending will require smarter choices on the part of health care payers and consumers. This research suggests that, in the short-term, consumers will not support payers making those decisions for them.

Paper 2: Hospital- and State-Level Factors Influencing Hospital EHR Adoption

Introduction

For several years, experts have heralded the promise of electronic health records (EHRs) while bemoaning their slow adoption in the United States. Despite government efforts to provide over 30 billion dollars in incentive payments for adopting and using EHRs, as of 2011 over 90 percent of acute care hospitals lacked a comprehensive electronic infrastructure[17]. This slow uptake leaves policy makers and IT advocates still searching for effective policy levers to increase adoption and drive the meaningful use of EHRs across the United States.

To inform the efforts to promote adoption of EHRs in American hospitals, this study evaluates the effects of several factors to determine their impact on hospital adoption of Stage 1 core EHR functions. I seek to identify appropriate "policy levers" – factors which are both influential and capable of amplification or reduction by policy makers in their efforts to drive increased adoption and meaningful use.

The rationale for the desirability of increasing adoption and use is based on prior research. Several studies point to the potential health, safety, financial, and productivity benefits of EHR adoption in the United States, with some suggesting annual savings across the health care industry of up to $81 billion are possible with effective implementation and networking[18–20].

Despite this potential, enthusiasm over the promise of health IT has been tempered by caution[21–25]. For the over 700,000 physicians and 5,000 acute care hospitals in the United States, providers have identified several realistic concerns, most notably the high cost of enacting new systems and training providers to take advantage of these tools in their workflow[26–28]. Furthermore, privacy concerns, delays in establishing clear consistent standards, and a lack of regional data exchange infrastructure have left many providers hesitant to begin the financial investment required to purchase

and maintain a comprehensive IT system, particularly when the party responsible for paying to implement an EHR system is not necessarily the party who will benefit from its implementation[18,29,30].

In the face of these hurdles, providers have made steady, if slow, progress. Annual surveys of hospitals conducted by American Hospital Association have found that the rate of hospitals possessing comprehensive electronic health records have moved into the low double-digits, with rates for all providers increasing by 3-6% per year[24]. Similarly, physician practices continue their slow ascent, despite significant differences in adoption rate between small and large group practices[31,32]. Adoption rates are expected to continue their ascent, likely at a more aggressive pace, thanks in part to federal and state efforts implemented to address some of providers' concerns.

In 2009, the federal government took a transformative step in promoting Health IT adoption with the passage of the HITECH Act. The 2009 Health Information Technology for Economic and Clinical Health Act (HITECH), passed as part of the federal stimulus package, signaled the United States' commitment at the federal level to addressing some of the hurdles preventing widespread adoption of electronic health records. HITECH allocates nearly $30 billion in incentive payments to physicians and hospitals who purchase and adopt electronic health records in their practices, along with the threat of eventual reduced reimbursement for those who do not comply[33,34]. Providers seeking these additional payments must demonstrate meaningful use of EHRs according to standards generated and updated by the Office of the National Coordinator for Health Information Technology (ONC) after broad stakeholder input. The first stage of these meaningful use requirements, enacted in 2010, set the baseline of requirements for data capture and exchange, and has widely been seen as a success. According to Ashish Jha, as of mid-2012 approximately 117,000 eligible professionals and 3,600 hospitals have received some form of incentive payment[35]. Stage two, released in August of 2012, builds on these requirements, particularly in the areas of patient interaction, data interoperability, and security[35].

Subsequent stages are expected to continue towards the goals of meaningful use through robust data capture and exchange[36].

These federal efforts build on years of state efforts to increase adoption of EHRs. Many states, through their legislatures and through direct executive actions, have encouraged adoption of EHRs by providing financing to hospitals and providers that predates the passage of the HITECH act and the initiation of federal incentive payments[37]. Legislatures have also targeted specific elements of health IT, including e-prescribing, clinical decision support, and state/regional health information exchanges[37]. Alongside the HHS Office of the National Coordinator for Health IT, states have formed an organization of their own, the State Alliance for e-Health, to share best practices and resources to further health IT adoption and meaningful use of EHRs[38].

Despite the fact that federal investment in EHR incentive payments dwarfs the amount invested through state efforts, there remains significant state-level variation in terms of the intensity of promotion and the extent of efforts to foster a favorable environment for private adoption of health IT. For example, looking solely at federal-level statistics obscures the fact that substantial state-level variation in hospital EHR adoption persists across the United States.

Study Aims and Hypotheses

This study examines how key state-level and hospital-level factors influence hospital adoption of electronic medical record functions. Further, it looks at how the influences of these factors change over time, with a separate analysis of the period after the stage 1 meaningful use criteria were specified by ONC. Lastly, this study will inform policymakers' efforts to increase effective adoption of EHRs across the full spectrum of American hospitals by identifying how state-level factors contribute to the rate of EHR adoption and pointing to effective policy levers for increasing adoption.

Three primary research questions drive this research:

1. Does state legislation designed to encourage EHR adoption have any measurable effect in increasing adoption rates among target hospitals?

2. How does hospital profitability affect the likelihood of adopting EHR functions?

3. Does the extent of hospital consolidation in a region affect the likelihood of adopting EHR functions?

Background

Before examining the influence of hospital- and state-level factors on hospital EHR function adoption, it is important to explain the context in which EHR adoption takes place. One can plausibly hypothesize that a multitude of factors come to bear on hospital EHR function adoption, including hospital margins, hospital market consolidation, concentration of teaching hospitals, state propensity to technological adoption, state ideology, and many others. Some of these factors are subject to amplification and reduction by policy makers, while others represent inherent hospital-specific or region-specific characteristics. Identifying policy levers requires identifying and controlling for influential-but-immutable factors to assess the true effect size of the remaining levers. Potential levers and controls are based on a review of the existing literature on EHR adoption, and the broader literature on health policy and technological adoption.

Historical Adoption Rates

In evaluating EHR adoption among hospitals, DesRoches et al. have conducted a longitudinal analyses of note, finding modest but increasing rates of adoption and adherence to the stage 1 meaningful use standards through 2008, 2009, and 2010, with more significant gains in 2011 – the first year in which incentive payments were available[17]. Jha et al. and others have pointed to significant variation in rates of adoption on the basis of hospital level characteristics, with teaching hospitals leading the way in adoption. Others, including McCullough et al., identify significant deficits in adoption

among critical access and other rural hospitals[39]. Of note, hospitals ineligible for incentive payments lag far behind their counterparts in adoption. Analysis of discrete elements of EHRs, such as computerized physician order entry systems, have also been conducted, with results consistent with the findings of Jha et al. that the rate of implementation remains low[40,41]. Additional research has looked at the development of regional infrastructure for meaningful use of EHRs. Adler-Milstein, Bates and Jha surveyed regional health information organizations (RHIOs) finding that, while the number of RHIOs in operation grew between 2007 and 2009, the scope of their activities remained limited[30].

Of note, Blavin et al. take a more optimistic view of hospital EHR adoption in the light of the final meaningful use rule for stage one, finding that just over 48 percent of hospitals meet half or more of the core meaningful use criteria[42]. Furthermore, they analyzed the AHA IT supplement by means of a principal component factor analysis and found that hospitals appear to use a "staged adoption strategy", adding related functionalities as necessary[42].

The patterns of adoption found by Jha et al., DesRoches et al., and other researchers suggest the tremendous influence of the meaningful use incentive payments on adoption. The pattern of slow, steady growth from 2008-2010 was significantly altered for 2011, the first year of incentive payments, with the share of comprehensive EHRs in hospitals growing nearly two and a half times. For the majority of hospitals, EHRs are still implemented in a piecemeal fashion, but significant growth from 2011 onward ensures that they will become increasingly integrated into the daily workflow across a range of units in the hospitals eligible for incentive payments.

Factors Influencing Adoption

Research by Jha et al. and DesRoches et al. has looked in detail at hospital-level factors affecting HIT adoption. Longitudinal data from American Hospital Association surveys of hospitals with regards to their HIT adoption plans have shown significant differences on several axes, with critical access, small &

medium, public, non-teaching, and rural hospitals less likely to have adopted EHRs than their counterparts. To quantify one such example, public and rural hospitals have 40 percent lower odds of adopting comprehensive EHRs than private non-profit and urban hospitals[23]. Similarly, Thakkar and Davis have evaluated factors influencing adoption, and present largely similar results. They add that maintaining privacy of data is seen by hospitals as the greatest potential risk in adoption EHRs, while data exchange within the facility seen as the greatest benefit. They find that cost is seen as the greatest hurdle to adoption, but add that with increasing hospital size, EHR cost is seen as less of a concern[43].

Value of EHRs

An increasing body of research attempts to demonstrate the value of EHRs in achieving the benefits described above to illustrate that they are more than hypothetical[44]. Among research attempting to quantify the impact of EHRs on health care quality, a variety of studies have yielded mixed results. Cebul et al. find that sites with implemented EHR systems are associated with significantly higher achievement of care for diabetic patients[45]. Similarly, Classen and Bates point to consistent quality improvement among facilities with internally developed EHRs and a lengthy history of use and iterative improvement[46]. Conversely, Walsh et al. found no significant improvement in the use of evidence based therapies for heart failure in outpatient cardiology practices, and Romano and Stafford point to the lack of consistent associations between EHRs and clinical decision support technology and better quality in a retrospective analysis of ambulatory patient visits[47,48]. However, Buntin et al. point out that, when reviewing the totality of the literature, a preponderance of published literature – 92 percent overall – suggests positive effects from the implementation of the various forms of health IT[49].

The experiences of hosts of other industries, along with preliminary analyses from short-term data in the health care industry, suggest that EHRs should effectively reduce health spending. Most published cost-benefit analyses to date have been theoretical, but models suggest positive value for the investment required. Wang et al. find an estimated net benefit for use in primary care of over $86,000

per provider over a five-year period, with the most pessimistic to the most optimistic assumptions ranging from a $2300 net cost to a nearly $331,000 net benefit[20]. Schmitt and Wofford also project financial returns from EHRs, provided an entire organization is considered as a whole[50]. Others disagree, with Sidorov arguing that a link to cost savings or reductions in malpractice premiums is yet to be established[51]. Furthermore, a recent paper by McCormick et al. finds that giving physicians electronic access to imaging and lab results does not result in cost savings, and may actually increase utilization[52].

The majority of published research suggests significant initial expenses as providers invest in the training and technology required to successfully implement an EHR, with net benefits coming after several years of use. It remains to be seen what type of EHR system will show greatest benefit, which is a significant limitation to any comprehensive study since the extent of variety across the industry is significant. Existing research suggests large differences in financial benefit/loss depending on the type of system and functions implemented[53].

Further, the extent of integration of any EHR into the workflow of the facility is critical to assessing financial benefits. And as a necessary-but-not-sufficient step towards broader reform, EHRs can promote further savings. By enabling better chronic disease management and earlier detection of illness and furthering the tools available for prevention (along with related changes to the health care system), Hillestad et al. predict that their estimated savings figure of $81 billion could be doubled[18]. Support for this theory comes from McMullin et al., who found significant savings in pharmacy costs by altering prescribing behavior with an e-prescribing system with integrated decision support[54].

State Variation in Technological Adoption

The extent of state variation in EHR adoption is clear when looking at the number of hospital beds meeting the core stage 1 meaningful use standard in the most recent survey year, 2011. While Hawaii and Vermont lead the pack with, respectively, 86 and 70 percent of hospital beds meeting the

threshold for incentive payments, 12 states have fewer than 10 percent of beds meeting this standard, and five states have no beds meeting the standard.

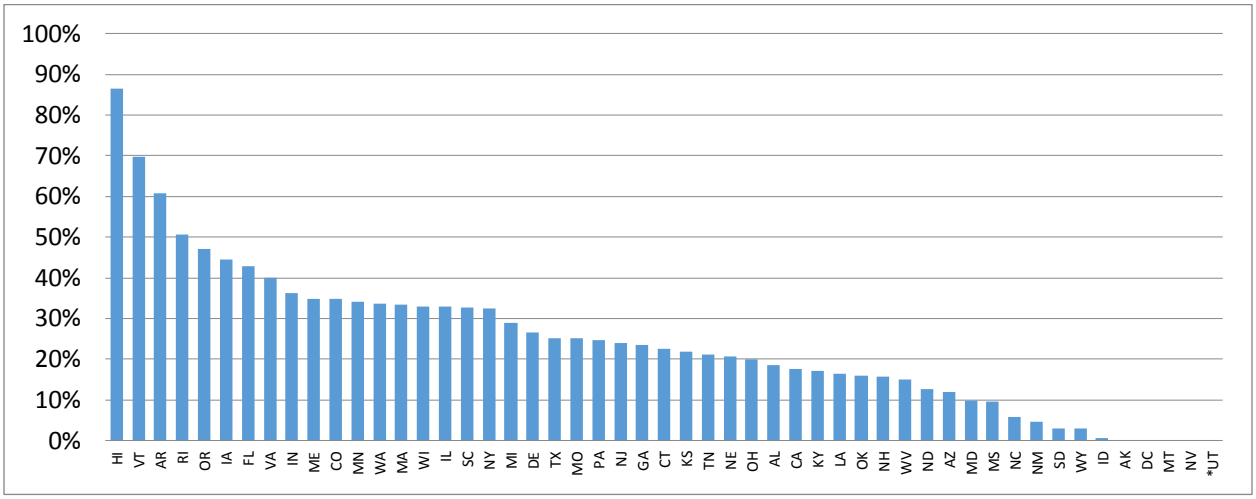


Figure 2.1: Percentage of Beds Meeting Core Meaningful Use Criteria - 2011
(Among Hospitals Responding to AHA IT Survey, Weighted for Survey Nonresponse)
n = 480,417 beds in 2646 hospitals
*Excludes Intermountain Health Care (did not respond)

Prior research also suggests wide variation in state-by-state adoption of new technologies, including new health care technologies. Skinner and Staiger look at state variation in technological adoption across a range of technologies, including technological advances such as personal computers, and agricultural advances such as genetically modified crops, and compare these to rates of education, income, and social capital. They find significant variation across states in rates of adoption, with adoption of technologies strongly associated with one another, as well as with social capital.

Furthermore, looking at adoption of new health technologies, Skinner and Staiger find that only 69 percent of admitted heart attack patients receive a beta blocker within 24 hours, as opposed to guidelines which recommend this step for all such patients. Once again, significant state-by-state variation is present in these results, which is correlated with other measures of propensity towards technological adoption[55,56].

Impact of state legislation

In particular, one area which is worthy of exploration is the activities of state legislatures. Looking back to 2007 and 2008, over 150 individual bills were passed at the state level pertaining to health information technology[37]. These laws vary widely in scope and direction – from dedicated funding for IT purchases to creating state agencies to promote and facilitate adoption. Despite this flurry of activity at the state level, little is known about the impact of state legislation in promoting health IT adoption. While the impact of the federal meaningful use program is widely analyzed, few studies have looked to evaluate the impact of the multitude of state laws providing funding for hospital health IT adoption.

A wide body of literature has examined the role of differential state policies on nationally relevant issues, often within the context of health policy. Scholars have assessed the variety of approaches taken toward potential genetic discrimination, evaluated the impact of malpractice legislation on suits filed and payouts, assessed approaches to structuring mental health parity legislation, and focused on the role of state efforts in regulating private insurance products, particularly managed care products[57–59]. Of particular note, Hall and Rich (2000) evaluated the impact of laws restricting health insurers' use of genetic information, finding no measurable impact given a lack of activity among insurers in attempting to solicit the information[57]. Across the range of these studies, most of the legislative efforts evaluated were targeting the prevention of a negative, rather than the promotion of a positive – a substantial difference from legislation seeking to promote EHR adoption. Ho and Liu look at the effect of state malpractice apology laws, finding that states with laws which exclude apologies from evidence at trial see average payouts which are $32,000 lower when an apology is given[60].

Methods

Data Sources

Data for this study has been assembled from several sources, each of which is described below.

American Hospital Association Annual Surveys & Health IT Supplemental – 2008-2011

During March–September of 2007-2010, the American Hospital Association surveyed all acute care hospitals about their health IT activities. A paper copy of the survey was sent to each hospital's chief executive officer, who asked the person most knowledgeable about the hospital's health IT efforts to complete it. The following number (percentage) of hospitals responded for each of the four years of the survey under consideration:

Table 2.1: AHA Survey Response Rates by Year

Year	Number of Hospitals Responding	Response Rate
2008	3450	63%
2009	4493	69%
2010	3635	64%
2011	2646	58%

The total sample size for the combined 2008-2011 datasets is 14,224 hospital response years.

Following the methods laid out in Jha et al. I measure the number of core Stage 1 meaningful use EHR functions adopted by each hospital[24]. A function is counted as adopted by a given hospital in a given year if the hospital responded to the corresponding question in the AHA survey by stating that the function or analogous capability was fully implemented in one or more units. Results were estimated using both weighted and unweighted models, and there were no significant differences. Unweighted results are displayed below.

National Conference of State Legislatures Reports – 2007 and 2008

Data on Health IT legislation for each of the 50 states and Washington DC is compiled from reports by the National Conference of State Legislatures, which compiles annual databases of legislation by category. Target legislation was then categorized more specifically on the basis of which elements of HIT adoption the laws sought to address.

State Propensity to Technological Adoption in Health Care

Data on state propensity for technological adoption, including the percentage of heart attack patients receiving beta blockers within 24 hours of hospital admissions in 2000/2001, was provided by Skinner and Staiger. The data are derived from large state-wide random samples of medical records conducted by the Centers for Medicare and Medicaid Services (CMS) and were originally assembled by Jencks et al.. (2003)[61].

Hospital Total Margins

Total margins were calculated from the 2007 Medicare cost reports. Medicare cost reports data was matched to each hospital by Medicare ID and AHA id, and the 2007 measure (the last year prior to the adoption data included in the study) was used to assess profitability prior to the adoption measured here.

Outcome Measures

The outcome measures for my research questions are number of stage 1 core meaningful use functions adopted. A function is considered adopted if it is fully implemented in one or more hospital units in a given year, as indicated by responses to the AHA health IT supplemental. The variable is a count variable, coded from 0-8 across years 2008-2011, and coded separately from 0-12 for years 2010-2011 for an additional set of analyses to take advantage of additional questions added to the AHA health IT supplemental during from those survey years onward. The 2010 and 2011 survey years include

additional information which allows adoption of four additional functions to be estimated. Analyses were conducted twice, once for all four years using a base of 8 core functions, and one for the final two years using a base of 12 core functions. Results from the 2010-2011 models showed no significant differences from the 2008-2011 models and are included in Appendix E.

Variable classification and coding specifications for outcome measures and independent variables are included in Appendix F**.**

Analysis Plan:

I calculated sample characteristics for each year of the sample and for the combined 2008-2011 dataset, assessing changes across years and by state over time. I then examined bivariate associations of each individual independent variable with the dependent variable for the combined 2008-2011 dataset, and separately for a 2010-2011 subset representing the years in which the stage 1 meaningful use regulations were publicly available. Results from 2010-2011 were not significantly different from 2008-2011.

I used multi-level poisson regression to examine cross-state variation in the relationship between hospital EHR function adoption and hospital and state level characteristics. Poisson regression is appropriate for count data such as the number of functions adopted in each of the four years assessed in the AHA survey.

The basic form of the model used is:

$$Log(E(Functs_{ij} \mid X_{ij})) = \alpha_j + \sum \beta X_{ij} + e_{ij}.$$

$$\alpha = \gamma_0 + \sum \gamma Z_j + \zeta_j$$

where 'Functs' is the number of EHR functions adopted by the ith hospital in state j, Xs are hospital-level variables and Zs are state-level variables. The model postulates that hospital level variables influence EHR function adoption and state level variables influence state-level adoption. The model also specifies error at the hospital level (e) and at the state level (ζ). The main questions of interest include how large are the Beta values for several variables of interest, how much are these values altered when other variables are added, do other variables have the hypothesized influences on EHR function adoption, how much cross-state variability is there in the Beta values for these variables of interest, and is this variability reduced by adding other variables to the model?

I applied multilevel longitudinal poisson analyses using the xtmepoisson and gllamm commands in Stata version 12.0 software (Stata Corporation, College Station, Texas). All analyses were applied unweighted using Stata's unweighted xtmepoisson command, and conducted with nonresponse weights using the gllamm command written by Rabe-Hesketh and Skrondal[62–64].

Results

To build to a final model, I tested several intermediate versions, which include controls and demonstrate the association between hypothesized factors and adoption of EHRs.

As expected from prior research, urban location, teaching status, and profit status all show strong associations with adoption of EHRs. In preliminary models, hospitals located in urban settings adopt 40% more EHR functions. Teaching hospitals also show a large positive association, with a 25% increase in the number of functions adopted relative to non-teaching hospitals. In contrast, for-profit

hospitals show a lower likelihood of adopting EHR functions, with 20% fewer functions than government and private not-for-profit hospitals. Including state propensity to technological adoption in the model reveals a positive association, with each percentage increase in the state rate of use of beta blockers in the 24 hours after a heart attack associated with a four-tenths of one percent increase in functions adopted.

Looking specifically at total margins, results suggest that hospital profitability is strongly related to EHR adoption. According to the models, each percentage decrease in hospital margins is associated with a 3-4% decrease in functions adopted, with exceptions at the highest and lowest ends of the spectrum after controlling for outliers. I coded total margins in several ways to identify patterns, and two methods were particularly instructive: looking at 5% increments of hospital margins and looking specifically at the hospitals most likely to be affected by financial policies, those closest to profitability. Results suggest that there is significant but small difference in adoption rates among profitable hospitals, but unprofitable hospitals show significantly reduced likelihoods of EHR function adoption. Figure 2.2 illustrates the relative differences among hospitals, segmented by profit margin. For example, an unprofitable hospital with margins between 0 and -5% is estimated to adopt roughly 7% fewer EHR functions than a profitable hospital. A severely unprofitable hospital – one with margins of -10% or greater, is estimated to adopt 15% fewer functions than a profitable counterpart. Hospitals further in either extreme, either extremely profitable or extremely unprofitable, suggest different patterns. Extremely unprofitable hospitals are less likely than break-even or slightly profitable hospitals to adopt additional EHR functions, but adopt more functions than other, less-unprofitable hospitals. This may be due to the fact that more of these severely unprofitable hospitals are government non-profits who have made a more direct commitment to HIT, and hospitals with a higher percentage of low-income Medicaid patients, which makes them eligible for higher payments through the meaningful use program, and thus a larger incentive. Conversely, while profitable hospitals are generally more likely than break-even

hospitals to adopt additional EHR functions, those at the highest end of the spectrum, hospitals with profit margins above 15%, adopt fewer functions than those just breaking even. This may be due to the higher concentration of for-profit hospitals among this category. As previously stated, for-profit hospitals are generally less likely to adopt EHRs than their not-for-profit counterparts, and this is reflected in profitability statistics.

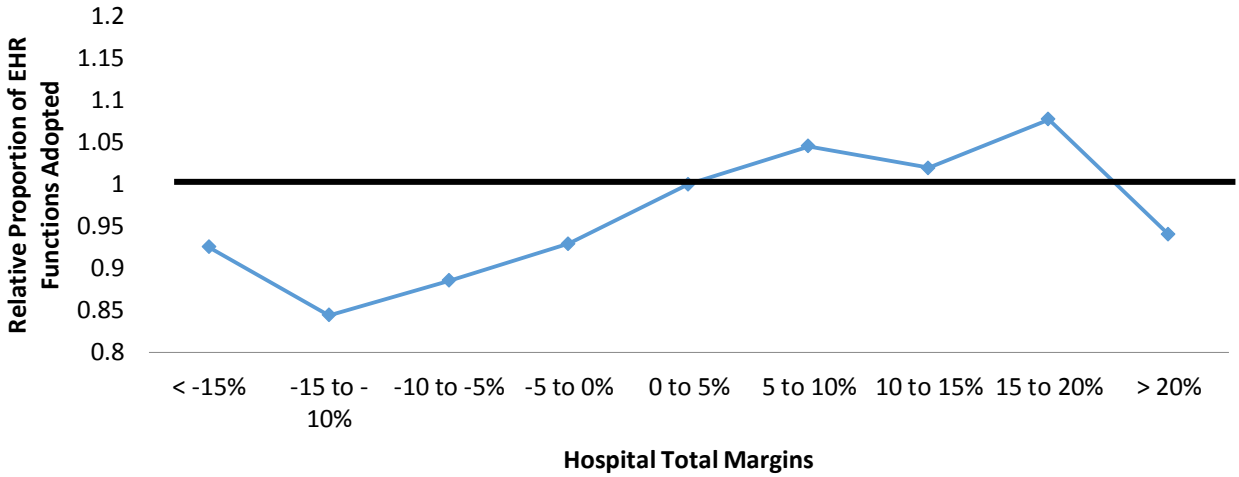


Figure 2.2: Relative Proportion of EHR Functions Adopted, by Hospital Total Margins

In subsequent regressions I tested the effects of state legislation regarding health IT, including hospital HIT financing, e-prescribing, health information exchanges, HIT privacy and security directives, and general comprehensive HIT legislation. None show a significant relationship when added to the model individually. However, when clustering standard errors at the hospital level, state legislation regarding privacy and security directives shows a significant negative relationship. Hospitals subject to state legislation directing them to take specific steps regarding data privacy and security adopt, on average, 8% fewer functions than hospitals not facing such legislation.

Additional models evaluated the impact of hospital and system size and system membership on hospital EHR adoption. As anticipated, increasing size and system membership are both associated with increased EHR adoption. Results suggest that a hospital that is a member of a hospital system is likely to

adopt just under 4% more features than a hospital that is not a system member. Results from including each category of system size (small, medium, and large) individually indicate that hospitals which are members of small or medium-sized hospital systems are no more or less likely to adopt more functions than individual hospitals not affiliated with a hospital system. Members of large hospital systems, however, adopt nearly eight percent more functions than unaffiliated hospitals.

Hospital size also shows a significant relationship with adoption of EHR functions. Medium and large hospitals are each more likely than small hospitals to adopt additional functions, with medium hospitals adopting nearly 18% more functions than small hospitals, and large hospitals adopting nearly a quarter more functions than small hospitals. Combined, these results suggest that the size of a hospital has a far stronger association with EHR adoption than does membership in a hospital system. A medium or large unaffiliated hospital is likely to have adopted significantly more EHR features than a small hospital in any size hospital system.

I also tested models including other factors hypothesized to affect EHR adoption, including regional hospital market concentration, state ideology, and the interaction of state HIT financing legislation and hospital margins (included in Appendix E). Results suggest that neither hospital market concentration nor state ideology have a significant impact on hospital EHR adoption. While state HIT financing legislation does not show a significant association on its own, the interaction of margins and state legislation shows a small but significant effect. In accordance with our earlier hypothesis, the results suggest a small effect of state legislation in promoting hospital EHR adoption in less profitable (or more unprofitable) hospitals.

Table 2.1 displays results from my final fitted model. Of note, the results show a small positive effect for hospitals in states with HIT financing legislation. This effect is most clear in nearly-break-even facilities, where such local financing can provide enough of a boost to make a comprehensive EHR adoption feasible for a facility struggling to tread water. The model includes a dummy variable for

hospitals just below break-even, those with margins between 0 and -3%. As indicated earlier, results indicate that these hospitals are less likely than other facilities to adopt EHRs. However, including an interaction identifying these below-break-even hospitals in states with HIT financing legislation shows a different outcome – rather than adopting over 10% fewer functions, these facilities in states with funding adopt nearly five percent more functions for each incremental level of financing available to them via state legislation.

Table 2.2: Multilevel longitudinal poisson regression results
Standard errors clustered at the state level

	Model 2.1.1
Urban Location	1.289*** (0.0167)
Teaching Status	1.225*** (0.0141)
For-Profit Status	0.802*** (0.0119)
AMI % betablocker	1.004* (0.00207)
Year	
2008	1 (.)
2009	0.972* (0.0122)
2010	1.342*** (0.0157)
2011	1.523*** (0.0188)
Hospital Total Margins (Decreasing)	0.958*** (0.00481)
State Legislation HIT Financing	1.007 (0.0119)
Hospital System Membership	1.063*** (0.00985)
Hospital Size	
Small	1 (.)
Medium	1.187*** (0.0130)
Large	1.226*** (0.0202)
0-3% Margin Hospitals	0.893*** (0.0212)
Interaction: Small Negative Margin * State HIT Financing	1.045*** (0.0120)
Observations	11300
AIC	55754.9
BIC	55864.9
Exponentiated coefficients; Standard errors in parentheses	
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001	

Discussion

Lessons for Policymakers and Advocates

The results suggest a multitude of factors influence hospital EHR adoption, with several subject to influence by policy makers. In particular, financing stands out as a significant lever, with hospital profitability showing a clear relationship with EHR adoption. For hospitals approaching the break-even point in their finances, state legislation appropriating funds for EHR adoption shows a clear positive effect, with hospitals in these states exceeding average adoption rates, while those in states without such legislation lagging behind the national average by over 10%. Policy makers can improve adoption rates with subsidies to those facilities with similar financial pressures. For such hospitals, the current structure of the Medicare and Medicaid meaningful use incentive programs, with their retrospective reimbursement model, do not create a large enough incentive to encourage comprehensive adoption.

Particularly as Federal incentive payments have become available, policy makers can see benefits from encouraging the sharing of expertise across hospitals. Hospitals able to quickly overcome the expected hurdles of implementation and workflow adjustment can realize the benefits of comprehensive EHRs much more rapidly. An understanding of best practices from successful hospitals offers the best opportunity to avoid the mistakes that come with trial and error and see rapid productivity, safety, and financial benefits.

The lack of progress among for-profit hospitals suggests the business case for adopting electronic health records has not yet been convincingly established. For-profits, which may have lower rates of Medicare and Medicaid reimbursement and thus are less likely to see significant reimbursement through meaningful use incentive payments, are adopting functions at a rate 15% below average. Policy makers should note that the short-term-carrot/long-term-stick structure of the HITECH act is having a smaller-than-anticipated effect on for-profit hospitals. With many for-profit hospitals seeing less of their revenue come through these channels, and the lack of belief in short-term financial benefit from EHR

adoption, this lag in adoption should come as no surprise. This limited participation, however, can slow ONCs efforts to bring about widespread health information exchange. Policy makers interested in increasing adoption among for-profit hospitals can either hope for incontrovertible evidence of the financial benefits of EHR adoption, or choose alternative "carrots and sticks" to target this subset of American hospitals.

Among rural hospitals, the problem of slow EHR adoption is both widespread and long understood. Despite the looming cuts in Medicare and Medicaid reimbursement without successfully attesting to meaningful use, rural hospitals face a host of challenges, of which EHR adoption is only one among many. Policymakers can target financial levers to increase adoption, and this research suggests those actions would have a positive effect. But rural hospitals require long-term interventions, not just a short-term influx of EHR-earmarked funds. Successful implementation requires process improvements and modifications after installation – improvements which can be influenced by prior experience of similar facilities, but are unlikely to come without significant expense and challenge for resource-limited facilities. Increasing market consolidation is unlikely to benefit rural hospitals when it comes to EHR adoption in the short term – the evidence here suggests that members of hospital systems see little increase in adoption relative to unaffiliated counterparts. The benefit of expertise from other member facilities may however, once meaningful use penalties are in effect, assist rural hospitals in their implementation efforts when their lagging adoption rates are translated into actual financial pain.

State-level results suggest that efforts concentrated in states with a history of technological adoption may lead more immediate benefit. The correlations between number of functions adopted from 2008-2011 and historical willingness to adopt new technologies do not point to a large effect size, but they do suggest that in health care, as in other industries where technology is crucial, some states are earlier adopters than others. Advocates may see greater short-term benefits by focusing their efforts

on facilities in such areas, where higher-than-average interest and cultural drive towards adoption can support their efforts.

Limitations

There are several limitations to this study. First, although response rates are high across each included year of the survey (averaging nearly 65 percent over the included four years), the results provided may not accurately reflect the full population of the nation's acute-care hospitals. Next, the AHA surveys do not ask specifically about the exact functions as described in the stage 1 final rule, but rather ask about these functions more generally. Jha et al. have specified a mapping of the AHA survey questionnaire to the stage 1 core meaningful use requirements, and I have adopted that mapping here. Furthermore, both the four-year estimates and the two-year estimates only measure a subset of the total set of core stage 1 meaningful use functions. Because of limitations in directly mapping AHA survey questions to core stage 1 functions, only 8 functions can be consistently measured for years 2008-2011, while 12 can be consistently measured for years 2010-2011. If the functions not included in the AHA survey questionnaires follow different patterns of adoption, those differences are not captured here. Finally, the fact that this is survey data leads to two further limitations: responses come from hospital staff (most frequently a hospital CIO), not independent observers, and the survey only accounts for implementation of the functions, not the extent to which they are used (and the appropriateness of that use).

Paper 3: Meaningful Use: Floor or Ceiling?

Introduction

The introduction of a health IT meaningful use incentive payment program as part of the 2009 American Recovery and Reinvestment Act has served as a powerful motivating force, driving hospital adoption of comprehensive electronic health records (EHRs) across the United States[17]. The program, which provides financial reimbursement for hospitals demonstrating their adoption and "meaningful use" of certified EHR systems, takes a step-by-step approach toward its goal of ensuring that the vast majority of US hospitals use comprehensive electronic systems by 2020. Hospitals must meet the requirements of successive stages of increasing requirements to receive the maximum funding available from the Medicare or Medicaid meaningful use incentive programs[65].

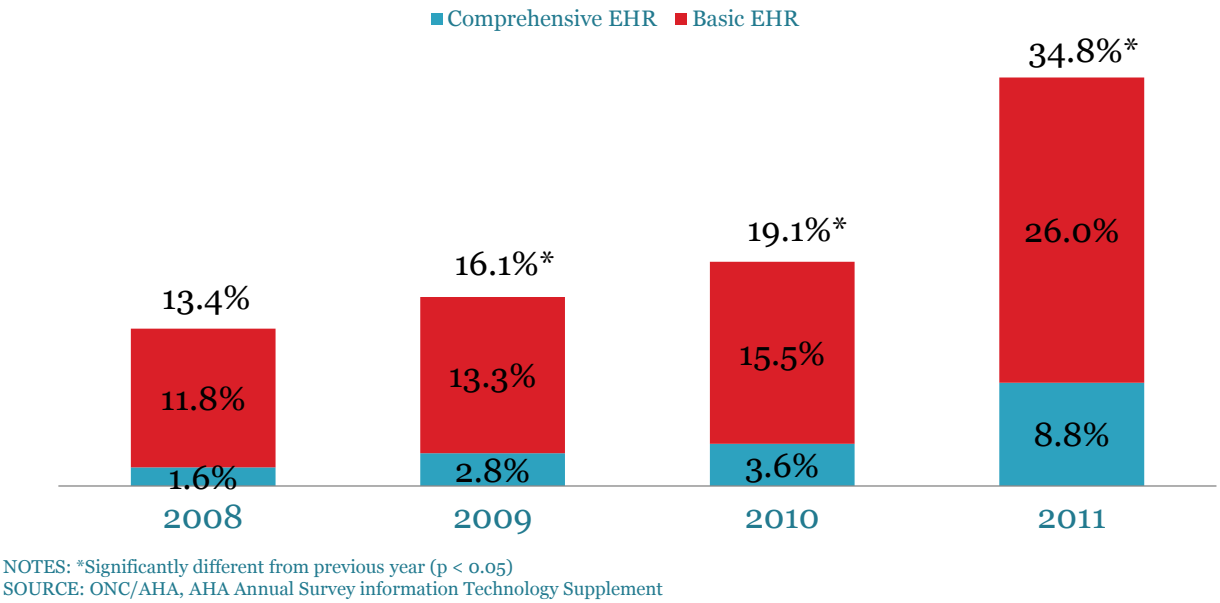
In 2011, CMS allowed hospitals to begin to attest to successful achievement of the stage 1 requirements - 14 "core" objectives and 5 of 10 "menu" objectives, each at pre-specified levels of use. The objectives, shown in Figure 3.1 below, include elements intended to improve the quality and safety of medical care, provide for electronic exchange of patient health information, and requirements for structured reporting and submission of clinical quality measures to facilitate evaluation and research.

Stage 1 – Core Objectives
CPOE (30% of all orders, including in the ED)
Drug-drug and drug-allergy interaction checks
Record demographics
Implement one clinical decision support rule
Maintain up-to-date problem list of current and active diagnoses
Maintain active medication list
Maintain active medication allergy list
Record and chart changes in vital signs
Record smoking status for patients 13 years or older
Report hospital clinical quality measures to CMS or States
Provide patients with an electronic copy of their health information, upon request
Provide patients with an electronic copy of their discharge instructions at time of discharge, upon request
Capability to exchange key clinical information among providers of care and patient-authorized entities electronically
Protect electronic health information

Stage 1 – Menu Objectives
Drug-formulary checks
Record advanced directives for patients 65 years or older
Incorporate clinical lab test results as structured data
Generate lists of patients by specific conditions
Use certified EHR technology to identify patient-specific education resources and provide to patient, if appropriate
Medication reconciliation
Summary of care record for each transition of care/referrals
Capability to submit electronic data to immunization registries/systems
Capability to provide electronic submission of reportable lab results to public health agencies
Capability to provide electronic syndromic surveillance data to public health agencies

Figure 3.1: Stage 1 Meaningful Use Requirements
14 Core Objectives (All Required) and 10 Menu Objectives (5 of 10 Required in Stage 1)

By February of 2013, it was clear that CMS had greatly exceeded its goal of 100,000 hospital and physician participants over the course of 2012. At most recent count, more than 230,000 health care providers have received payments from the Medicare and Medicaid incentive programs, with total outlays exceeding $12.6 billion dollars[66]. Among hospitals, nearly 4300 have registered for stage 1 of the incentive program, receiving over $8 billion in payments. Research by DesRoches et al. and others suggests that the meaningful use incentive program has been successful at increasing the number of hospitals pursuing comprehensive EHR adoption, but overall adoption is still progressing slowly, particularly in small, rural, and non-teaching hospitals[17]. As shown in Figure 3.2, from 2010 to 2011, the rate of hospitals possessing comprehensive EHR systems more than doubled, from 3.6% to 8.8%.



NOTES: *Significantly different from previous year ($p < 0.05$)
SOURCE: ONC/AHA, AHA Annual Survey information Technology Supplement

Figure 3.2: Hospital EHR Adoption Rates
Percent of non-federal acute care hospitals with adoption of EHR systems, by level of functionality
2008-2011

To date, Jha et al., Desroches et al. and others have highlighted the extent of comprehensive EHR adoption, and important variations in adoption by key hospital characteristics. But little has been done to find variations in which functions hospitals are adopting, and how hospitals are choosing which functions to adopt.

Within the HIT industry, increased adoption has meant new opportunities and challenges for both EHR vendors and hospital CIOs. Yet we know little about how vendors and CIOs have responded to the meaningful use incentives in their planning and development – in other words, how the meaningful use incentives have altered decision-making within the industry. Given the significant effort required to meet the requirements set forth in stages 1 and 2 of the meaningful use incentive program, policy makers should be aware of whether vendors and CIOs are viewing the meaningful use requirements as a floor – the minimally acceptable level of implementation, upon which they will continue development

and customization – or as a ceiling – the upper-bound on their EHR development and implementation efforts.

Historical Efforts

The EHR incentive program is one of many efforts by the federal government and states to increase demand-side incentives for desirable technology. As such, there exists a body of literature studying the effects of incentive programs for non-incremental technical change in other fields, notably alternative energy technologies such as photovoltaics and wind power. Existing research is consistent in finding that large-scale incentive programs are successful at spurring increased adoption[67–77].

Despite the frequent claims that incentivized technologies will "pay for themselves," existing research explores the factors which complicate adoption[78]. Nemet points to two key findings from prior government-led incentive programs which are broadly applicable to the EHR incentive program – 1) rapid convergence on a single dominant design limits the market opportunity for non-incremental technical improvements, and 2) uncertainty over the time in which benefits of new technology will be realized dampens the incentives that demand-side policies create[79]. Mowery and Rosenberg second this, noting that the technology still must be integrated into the workflows of existing systems, which for large entities often requires the development of supporting technologies before users can comfortably adopt the new technology[80].

Existing research also suggests that the size of entities targeted by incentives matters in determining their adoption abilities. Kerr and Newell find that larger entities adopt incentivized technologies sooner than their smaller counterparts, which they suggest can be attributed to greater economies of scale, as well as increased access to investment capital, higher management quality, and greater participation in research and development activities[67]. They also find, however, that higher levels of previously installed technology have a dampening effect on adoption, which may prove to be

relevant in the rapidly evolving world of hospital EHR technology. The literature suggests that adoption of high-technology innovations requires large capital investments and substantial human resources. In this study, I look specifically at how the market for hospital EHRs has been affected by the initiation of the EHR incentive program, both for consumers and for producers, identifying ways in which it is consistent with prior research – largely from energy incentives – and ways in which it is unique to this specific effort.

Study Aims and Hypotheses

This study aims to identify how vendors and hospital CIOs have responded to meaningful use incentive payments, in terms of their decision-making on which functions to develop/adopt, and at what time to develop/adopt them.

Regarding the "floor or ceiling" question, one can plausibly hypothesize either outcome - that the meaningful use requirements are being treated as a baseline for further development, or as a limit on the extent of what an implementation will include. Given the limited development time and manpower for vendors and the significant expense for hospitals to add, customize, and train clinical staff in the use of additional features, it is possible that the requirements are serving as a ceiling on development and implementation. However, given the desire to differentiate products in the marketplace and the need to customize EHR implementations to the specific needs of individual hospitals and hospital systems, viewing the requirements as the lower-bound, above which further development and customization continues to take place, can also be supported by existing theory.

Study Data and Methods

I use a mixed-methods approach, combining semistructured interviews with EHR vendors and hospital CIOs from across the United States with survey data from the American Hospital Association (AHA). In particular, I compare the adoption rates over time of two distinct functions with the shared goal of preventing medication errors – bar code medication administration (BCMA) and computerized

physician order entry (CPOE). Bar code medication administration is a computer-aided system designed to ensure that the "five rights" of a patient are maintained – that the correct patient receive the correct medication, at the correct dose, at the correct time, by the correct method of administration. It is most often managed by nursing staff at the point of administration, helping to reduce errors and maintain precise records of medications provided in the hospital.

Computerized physician order entry seeks to meet this goal at the point of order, providing a precise method for physicians to transmit orders to other staff or other departments, including pharmacy, laboratory, or radiology. CPOE helps reduce medication errors by minimizing the possibility of transcription errors and duplicative treatments or tests, and can combine with clinical decision support tools and stored information on allergies and other medications to avoid harmful interactions and improper or wasteful treatments.

The two elements vary in their cost, time to implement, and their status with regards to meaningful use requirements. CPOE is the more expensive and time-intensive of the two, with estimates for cost and time of adoption placing the figures at approximately $34,000 in five-year costs per bed[81–83] and 1-4 years per facility[83,84]. BCMA adoption, by contrast, is estimated at averages of $3,000 per bed[85–87] and 4-6 months per facility[87]. While CPOE is included as a core function in stage 1 of meaningful use, BCMA was not required (or listed as a menu item).[1] This provides an opportunity to track the growth rates of adoption of the two functions, which prior to the release of the stage 1 requirements held similar levels of support among HIT experts and analysts when evaluating clinical benefits[82,88,89].

Quantitative Component – Data Collection

American Hospital Association Annual Surveys & Health IT Supplemental – 2008-2011

[1] BCMA or equivalent functionality has since been included as a requirement in stage 2, but this would not have been known at the time hospitals and vendors were making decisions with regards to meeting stage 1.

During March–September of 2007-2010, the American Hospital Association surveyed all acute care hospitals about their health IT activities. A paper copy of the survey was sent to each hospital's chief executive officer, who asked the person most knowledgeable about the hospital's health IT efforts to complete it. As noted in Table 2.1, the sample represents 14,224 hospital response years across four years of data collection.

Following the methods laid out in Jha et al. I measure adoption of specific EHR functions in each hospital[24]. A function is counted as adopted by a given hospital in a given year if the hospital responded to the corresponding question in the AHA survey by stating that the function or analogous capability was fully implemented in one or more units. Results were estimated using both weighted and unweighted models, and there were no significant differences. To demonstrate overall penetration, results weighted by number of beds are included below.

Qualitative Component – Data Collection

Interviews with hospital CIOs

I conducted semistructured interviews with the Chief Information Officer (CIO) or equivalent senior staff member directly responsible for EHR adoption decision-making at 17 hospital systems and independent hospitals, representing a total of 144 individual acute-care hospitals[2]. Respondents were responsible for a mix of small, medium and large facilities in urban and rural locations as well as a mix of for-profit and not-for-profit, and teaching and non-teaching facilities. Respondents varied greatly in size, with the smallest hospital approximately a 25-bed facility and the largest holding nearly 850 beds.

[2] Of hospital respondents, 13 represented hospital systems and 4 represented individual hospitals.

Table 3.1: Characteristics of the 144 Hospitals Represented by Respondents

Characteristic	Mean number/percent
Number of Beds	283
Teaching Status	
Teaching Hospitals	35%
Non-Teaching Hospitals	65%
Location	
Rural	28%
Urban	72%
Profit Status	
Not-For-Profit	52%
For-Profit	48%
Geographic Region	
Midwest	18%
Northeast	25%
South/southeast	55%
West	2%
Hospital System Membership	
System Member	96%
Unaffiliated	4%

Respondents were contacted by e-mail or telephone. Representatives of 10 leading hospital health IT vendors were contacted and 8 agreed to participate. Among hospitals, 45 CIOs from hospitals and hospital systems were contacted and 17 agreed to participate. All consenting subjects were interviewed by phone. Hospital CIO interviews included open-ended questions about how hospitals decided when to adopt EHRs, which functions they chose to adopt, and how stages 1 and 2 of the meaningful use regulations affected their decision-making.

Interviews with EHR Vendors

I conducted semistructured interviews with Vice Presidents of Product Development or equivalent senior staff at eight hospital EHR vendors. To identify subjects for these interviews, I referenced HIMSS data on the top 10 EHR vendors by number of current hospital installations in 2012 and contacted the lead executive in charge of product development at each company. According to HIMSS data, the 8 vendors contacted represent over two-thirds of all current hospital EHR installations. Vendor interviews included open-ended questions about how vendors made decisions on which

functions to develop and improve, and how stages 1 and 2 of the meaningful use regulations affected their decision-making.

All interviews were conducted from December 2012 to March 2013. To preserve anonymity, no identifying characteristics of the individuals contacted or the companies/hospitals they represent have been included here. All respondents, regardless of gender, are referenced using male pronouns to avoid identifying individual respondents. Data collection was approved by Harvard's Institutional Review Board and appropriate confidentiality and data security procedures were followed.

Study Results

Among hospitals pursuing adoption, the majority met the floor requirements of meaningful use and continued development above and beyond the minimum standards to receive incentive payments. Consistent with prior research on government incentive programs, the data also suggests that large and medium-sized hospitals have made more progress than smaller facilities in their adoption of EHRs. Analysis of the specific functions adopted by hospitals, and discussions with vendors and CIOs, reveal much more detail in terms of how decisions have been made, and what is motivating the development and inclusion of individual EHR functions.

When comparing the rates of adoption of CPOE and BCMA in Figure 3.3, the effects of CPOE's inclusion in the stage 1 meaningful use criteria are clear. Adoption of medication barcoding progresses steadily from 2008 to 2011, increasing from about 39 percent in 2008 to just over 60 percent in 2011, the first year when incentive payments were available. In contrast, CPOE adoption increased at a more gradual rate, reaching nearly 45 percent in 2010, but growing by nearly twenty percentage points in advance of incentive payments in 2011. This behavior is consistent with hospitals investing in CPOE in advance of the deadline to attest their compliance with stage 1 of the meaningful use regulations and receive incentive payments[84]. Hospitals required the addition of CPOE functionality to reach the floor,

but did not cease adoption of additional features. The growth of BCMA adoption illustrates this finding. BCMA adoption did not slow because of its lack of inclusion in stage 1, but rather increased at a pace slightly above that of the prior three years.

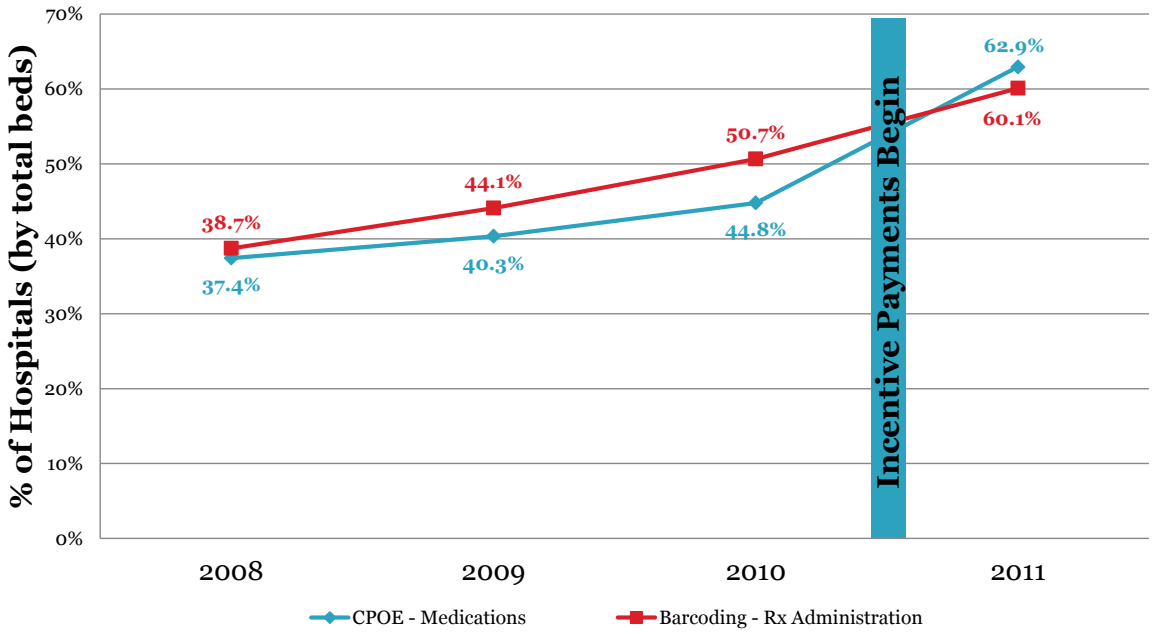


Figure 3.3: Percentage of Hospitals with Function Implemented in at Least One Unit

Qualitative interviews with hospital CIOs revealed multiple differences in hospital behavior depending on the size of facilities and the status of health IT implementation prior to pursuing meaningful use incentive payments.

Medium/Large and Urban Hospitals

Among medium and large hospitals, particularly those designated as teaching hospitals, most already had several elements of EHR technology in place, and sought to develop their EHR implementations above and beyond the requirements put in place by stage 1 of meaningful use. In most cases, implementations prior to the release of the stage 1 criteria included some form of clinical

documentation, clinical decision support, and BCMA. Meeting the stage 1 criteria most often required adding CPOE to their existing installations, and adjusting their data capture requirements to add new fields and adjust existing fields in accordance with the stage 1 criteria. As one CIO from a large urban facility noted, "we hadn't done CPOE – that was the only major element. Everything else was kind've perfunctory – getting the right fields in the right places." Respondents generally commented that the inclusion of CPOE in the meaningful use requirements led them to pursue its adoption sooner than they otherwise would have. "The goal became to attest and get the money as soon as possible," one CIO noted. "Meaningful use gave us the drive of this money as a motivating factor." Regardless of the financial incentive, CIOs still faced a significant challenge in reaching the use thresholds for CPOE that stage 1 requires:

> BCMA was already active here, and I found that to be a very easy transition compared to CPOE. It was much easier to get the nurses to go along with using new equipment, compared with getting a doctor long since set in his ways to adjust his workflow.

However, inclusion in the stage 1 criteria helped CIOs convince clinical staff that the transition to CPOE would be worthwhile. With the external published standard indicating that CPOE would eventually be required to maintain Medicare and Medicaid reimbursement, motivating physicians became less of a challenge. "It has taken away some of the push-back you get from the clinical users," another CIO noted. "When you introduce changes into the lives of high-functioning clinicians, you're going to get push-back no matter what, but with the criteria published we don't have to spend as much time explaining the decision [to implement CPOE] as we would have." All respondents from medium and large hospitals commented that, regardless of its absence from stage 1, they either already had BCMA in place, or chose to implement it alongside their upgrades for meeting the meaningful use requirements.

Given the requirements, many facilities with pre-existing installations saw the incentive payments not just as an opportunity to make incremental improvements to their existing infrastructure, but rather to take on a more complete overhaul or total replacement of their HIT capabilities. In

particular, CIOs of hospital systems made the decision to use their incentive payments to help in an effort to move their HIT towards integrated EHRs that would use one unified patient health record across the entirety of their implementation, as opposed to fragmented approaches across different hospital departments and facilities. As one hospital system CIO commented:

> Organizationally, because of meaningful use our goals changed, and the technology we had wasn't going to help us meet those goals. So we made the decision to change our vendor. Our prior system wasn't integrated. As you moved settings, records weren't available. You could try to interface the systems, or exchange data from one to another, but the exchanges were buggy. We wanted an integrated system. So we made the decision to change, and now we are implementing a new system.

Respondents pointed to the expense of attempting to get existing functions to work together and maintain effective data exchange in the face of software updates and bug fixes that often disrupted the custom interfaces put in place to exchange data across hospital departments. Prior research from Rogoski (2012) and others also points to the difficulties hospitals and physician practices have faced with real-world interoperability challenges, despite claims from vendors that systems will interface without difficulty[90]. Another CIO pointed to the following:

> Our vendor has been great about communicating with us about what it was going to take to attest for stage 1. We just wish their product didn't have so many issues. And it's not just them. So many vendors were trying to deliver products so quickly that they were full of bugs. For us, that meant lots of defects, lots of workarounds, and lots of patches. I think the time constraints affected quality.

Such continuous challenges led many to encourage hospital leadership to pursue new solutions.

Of note, several hospital CIOs shared their experiences in operating in a post-merger environment, where hospitals with systems from disparate vendors were being acquired or merged to form larger hospital systems. In these instances, data exchange between facilities with EHR implementations from different vendors proved technically challenging. While most commented that they were able to upgrade and modify their existing implementations to successfully attest for reimbursement under the stage 1 requirements, their significant doubts about the ability of older systems to meet increased demands and successfully exchange data with EHR systems from other

vendors now present in their hospital networks led them to pursue a single, unified solution for their hospital system.

For those CIOs pursuing new implementations alongside their existing systems, timing is of the utmost importance. For large facilities, complete implementation of a certified EHR capable of meeting stage 1 & 2 requirements generally requires a multi-year effort. Given the timeline under which hospitals must successfully attest to their compliance with subsequent stages of the meaningful use regulations, several hospitals have chosen either to forego large scale changes to their systems until the conclusion of the incentive program, if ever, to rush through an implementation of a new EHR in a condensed time frame to attest for stage 2 with a new system, or to pursue a dual-system strategy. Several CIOs with whom I spoke noted that their approach has been to pursue stage 1, 2, and beyond with their existing system, while simultaneously installing a new system for future use. With this approach, they believe they can successfully attest and receive the incentive payments they need to help fund implementation of the systems which will better serve their facilities in the years to come. As one CIO noted:

> This is a strange situation. Making the switch to [vendor 2's system] takes so long to implement that, if we want to keep getting the reimbursement from meaningful use, we have to maintain [vendor 1's system] and keep updating it to hit stages 2 and 3. We've already started implementing [vendor 2's system], but they're going to have to get used side by side for 3-5 years while we get this done.

Among these experienced facilities, EHR implementations were generally comprehensive, designed with the goal of meeting and exceeding the meaningful use criteria to attain maximum clinical benefit. Aided by their experience with earlier EHR components in the facility, CIOs pointed to effective collaboration with Chief Medical Officers (CMOs) in viewing EHRs as being a matter not just of information technology implementation, but as the implementation of new clinical improvements in the provision of care.

While one of the most frequent criticisms of the meaningful use incentive program came from CIOs struggling to maintain interoperability between functions from different manufacturers in the face of frequent updates and bug-fixes as well as hospital system consolidation, several pointed to additional hurdles they have faced in choosing and maintaining comprehensive electronic health records at their facilities. In particular, CIOs noted challenges in improving usability, limited options available for hospital specialties, and an inability to devote time to focusing on technology that would assist nursing staff. Usability issues were a common refrain when asking CIOs about challenges brought about by meeting stage 1 of meaningful use. CIOs pointed to two factors – limited willingness from vendors to make general usability improvements, and limited ability on the part of CIOs to modify order sets and structure reporting fields to improve the experience for clinical staff. As one CIO noted:

> The vendors quit working on usability factors – the things we had been asking for to make things work more smoothly, particularly for the doctors. If it wasn't for HITECH, we would have been doing this much more gradually, and it would have been much more measured in a more casual time frame. Instead, we had to hurry, and that meant less time to customize and tinker.

For facilities with existing implementations, many CIOs also suggested that their development road maps were altered, in that plans for system improvements had to be delayed to ensure their systems would meet the stage 1 requirements. Several pointed to improvements in workflow for nursing staff as an area where they saw opportunities to improve the provision of care, but have chosen to delay their efforts, a finding consistent with prior research on stagnation in the development of nursing clinical information systems:[91]

> We haven't revisited our nursing documentation, other than to tweak for regulations to support CPOE, in over 10 years. We've taken new releases of packages with other capabilities, but we were so busy doing meaningful use that we didn't have time to look at nursing, and I think that's a shame. Instead, I was occupying my time trying to figure out how to give a patient a copy of their record on a thumb drive. Plus, the quality metrics, which were a lot of dotting of i's and crossing of t's to prove that we had done what we said we did.

> We're not doing things that would be great for nurse productivity, like interfacing IV pumps and monitors into our system. It takes a lot of time and money, and we don't have that. Those would've been great projects that we had on our plan that we keep pushing off because we have to keep doing all this other stuff.

Additionally, hospitals with active specialty departments pointed to challenges in finding appropriate solutions to implement that would accommodate the workflows typical to those departments. In particular, hospitals pointed to mental health, physical therapy, and surgery as areas where they found few appropriate solutions to implement. Furthermore, several CIOs noted that including historical lab information in records had proved more challenging than anticipated, particularly for areas such as historical mammography data, which oncologists would like to have on hand but are often still relying on legacy systems to view. Customizing the available options to meet the needs of practitioners in those departments would have been too time-intensive, and thus they have often seen EHR implementation delayed.

Small and Rural Hospitals

Among smaller facilities, particularly those with less (if any) experience with health IT prior to the introduction of the meaningful use incentive program, transitioning to comprehensive electronic health records has come with a different outlook and its own unique set of challenges[92]. In many cases, meaningful use is seen as a ceiling – one which they will struggle to reach and keep pace with as subsequent stages increase requirements. As shown in Figure 3.4 below, overall adoption of certified EHRs has lagged for small hospitals (those with fewer than 100 beds, according to AHA classifications) relative to large facilities (those with 400 or more beds). A lower share of small hospitals possessed either CPOE or BCMA, but the trend of greater increased adoption of CPOE relative to BCMA in the last year prior to incentive payments held similarly.

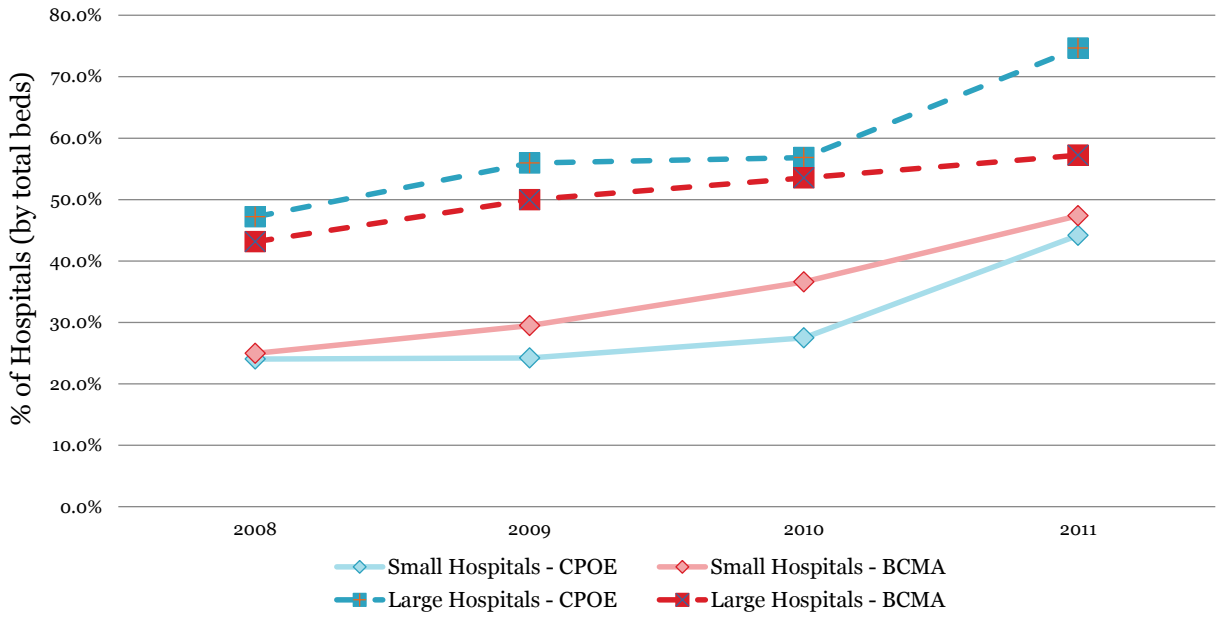


Figure 3.4: CPOE and BCMA Adoption Over Time, by Hospital Size

CIOs of small hospitals suggested that, in most cases, incentive payments provided the impetus for their decision to adopt comprehensive EHRs. This transition entailed a more abrupt change in workflows for practitioners in many small and rural facilities, who were starting their EHR adoption from a lower level of familiarity with EHRs[93]. While many had held preliminary discussions about clinical value and cost of implementation, most small hospital CIOs with whom I spoke noted that they had neither the financial nor the staffing resources to implement comprehensive EHRs prior to the introduction of the incentive program, and faced internal opposition among clinical staff as to their participation. Most noted that, given the difficulty they faced in implementing any system at all, they focused predominantly on meeting the minimum threshold of what was required to receive incentive payments:

> I wear probably 4 or 5 hats here. I do pretty much whatever they throw at my desk. So trying to research the EHR companies, setting up meetings, buying all the equipment - nothing else got done. We concentrated solely on Meaningful Use.

> We just wanted to get meaningful use. So we went with the CPOE and patient registration -- just the components required for meaningful use. We totally concentrated on meaningful use. And now we'll add modules as we go to keep it up.

In these cases, CIOs noted that their decisions were made primarily on the basis of price, with a secondary factor being the extent to which the vendors could demonstrate a track record of success with similar hospitals, particularly for those facilities located in rural communities. Several CIOs noted their concerns about ongoing maintenance and fees associated with their installations in subsequent years. Because they are partially relying on subscription services to manage functions like clinical decision support, e-prescribing, vocabulary servers, and (as of stage 2) patient portals, they have little control over price increases once they are locked in with their current service providers, and limited ability to switch to alternative providers that will work seamlessly with their existing installations. Several vendors suggested that they saw little value for patient engagement tools given the demographics of their patients, who were unlikely to use the technology, particularly as stage 2 requirements making personal health record use mandatory will place an additional burden on hospitals to motivate patient engagement where none currently exists[94]. Among these facilities for whom price was the primary concern, functions excluded from stage 1 of the meaningful use requirements, such as BCMA, have not yet been adopted, but will be adopted in advance of stage 2 and as required for continued incentive payments.

A minority of respondents from small hospitals suggested that, once the decision was made to meet the meaningful use criteria and pursue reimbursement, CIOs partnered with CMOs to pursue more functionality in the interests of improved patient care. That shared approach between clinical leaders and IT leaders within the facility helped overcome initial opposition on the part of clinical staff:

> This wouldn't have happened without the [meaningful use incentive] money. We would have waited until we were forced in some manner to go to electronic records. There wasn't enough money and there wasn't enough of an incentive out there. We went beyond just what was required because our CMO is very much into quality patient care and wants to use electronic systems to help meet those goals. We are not going into this just to meet meaningful use and

> this is not an IT project. This is a clinical project. That message helped with buy-in across the whole hospital.

In other cases, CIOs suggested that, while the incentive payments sped up their adoption timeline, they would have implemented plans to adopt some form of electronic health record, if not one that fully met meaningful use requirements, in the medium-term – within the next 5-10 years. One CIO of a rural hospital suggested that regional competition and the opportunity to exchange data with nearby facilities was making adoption inevitable:

> Without [meaningful use] we would have eventually done something. We were already talking about it before the HITECH act came about because all the larger hospitals were doing it around us. We were glad to see the opportunity for this money to help us get started. But we wouldn't have done CPOE otherwise. It's been the death of me trying to get our physicians to cooperate.

Difficulty persuading physicians to adjust their workflows to incorporate CPOE was a common theme among CIOs of smaller facilities. Many CIOs pointed to the fact that the majority of physicians practicing at their hospitals are not salaried by those facilities as a significant stumbling block when trying to persuade physicians to alter their workflow. Across all discussions, CIOs contended that adoption of EHRs in general, and CPOE in particular, was much less controversial among salaried clinicians, with whom facilities hold more authority. While some may have had difficulty adjusting to new workflows, most salaried clinicians worked with hospital staff to incorporate stage 1 requirements into the provision of care. Without the powerful motivating force of hiring and firing ability, however, facilities have had little ability to cajole long-tenured physicians into entering their own orders. One CIO explained the challenge he currently faces in persuading his staff to adopt the technology:

> As of two months ago, we've started a pilot program using CPOE, and about 5 percent of our physicians agreed to try. None of them are our employees, so we can't compel them to use the EHRs. They keep saying that if we give them all iPads, then they'll do it. If we make it [to the minimum threshold], it'll only be because of pharmacy orders and nursing orders. If we had to count on [non-salaried] physicians, we would fall on our faces.

Some of the CIOs with whom I spoke pointed to efforts within their facilities to negotiate with medical staff committees to change the requirements on physicians with admitting privileges. Given their lack of

leverage, however, some facilities are anticipating having to structure agreements to share hospital incentive payments with affiliated, non-salaried physicians to ensure their participation. Other facilities focused exclusively on implementing CPOE in their emergency departments, which would count for enough of the hospital's total utilization to meet the thresholds for stage 1 and which were staffed with salaried physicians who were more willing to comply with hospital directives.

Other CIOs placed the blame more squarely on a lack of familiarity with information technology in general. "I have an older physician staff that's not computer savvy," one CIO pointed out. "What do you do with people who can't type?" These CIOs also noted that they expect this trend to change over time, as younger physicians with more experience and training in the use of EHRs specifically (and computers more generally) would lower the barriers to entry. Particularly in rural facilities, the lack of familiarity among older physicians with IT was pronounced – several CIOs relayed stories of elderly physicians never having migrated from typewriters to personal computers. One CIO pointed out how the demographics of his clinical staff made the transition particularly difficult:

> Where we are, the location, the style of the community -- the physicians that we attract, many of them are coming in for semi-retirement jobs where they work half-time. In essence, they're all older. So it's really tough to get them to change, especially if they're not an employee.

Some rural facilities shared that their workflow now includes having a nurse accompany each physician on rounds, personally assisting them with retrieving information from and entering orders on terminals across the facility. In other cases, physicians maintained their paper charting, and nursing staff duplicated these efforts into electronic records, with both sets of records being maintained for at least the next several years.

Vendors

Discussions with vendors revealed an industry which was given new development incentives with the introduction of the meaningful use incentive program. With the requirements put in place for reimbursement, vendors now had a new business case to make in favor of potential functions which had previously gone ignored, and no longer had as strong of a case for some of the functions on their road map which would now be delayed. In general, as with hospital CIOs, vendors were broadly positive about the effects of the meaningful use incentive program both on their businesses and on the state of EHR software in the marketplace. They viewed meeting the meaningful use requirements essential to their viability as a software partner for hospitals, but also saw their continued development and implementation expertise above and beyond the requirements as a source of positive differentiation in the marketplace. Most, however, noted that meeting the requirements had been challenging for vendors and clients alike. One vendor gave his view on how his company and its clients have reacted thus far:

> I think everything that's been done, in my mind, has been a good thing. It's just the pace has been difficult for us to manage, both for us, in terms of everything else that we'd like to do that we cannot do, but also for our existing clients because they now have new ongoing costs, they have to add additional servers, they have to upgrade their hardware – those things take time, and there's cost involved. They're getting reimbursement money, but they don't want to give us all of it, and they don't want to give the content partners all of it.

Vendors were unanimous in pointing to interoperability, public health reporting, and patient engagement tools as an area where function development was motivated almost exclusively by their inclusion as requirements for meaningful use reimbursement. Another vendor described the change in their planning with respect to interoperability as follows:

> I think interoperability as a development area didn't exist at all before stage 1 in our company, and now it's an area that is very, very busy in terms of our effort. Meaningful use forced our hand in terms of putting the financial incentives in place for us to do it.

Similarly, vendors were consistent in their statements that patient data interaction capabilities, which were originally later on their development road maps, were brought forward rapidly to meet stage 1

and 2 requirements. In particular, the abilities to deliver care summaries, for patients to view, download, and transmit their data, and patient portals with secure messaging capabilities were noted as areas where development was fast-tracked relative to initial planning. In part, this has to do with remaining unsolved questions, including how to decide which laboratory results should be included in accessible patient records, particularly when laboratory results may come in the form of proprietary data formats several gigabytes in size without publicly available software to facilitate their viewing.

Vendors also pointed to seemingly minor changes which required significant coding and testing over a shorter time frame than they otherwise would have been comfortable shipping products. In particular, vendors noted that the stage 1 requirements required re-shaping many unstructured fields to structured fields and providing mechanisms for automated reporting of clinical quality data. In several cases, vendors commented that they were delayed in having to re-design functions once test data was made available for processing from CMS, to ensure that they were strictly matching data formatting requirements.

Several vendors pointed to the approach of the federal government in disseminating standards for required data elements for each quality measures, arguing that they needlessly varied from existing standards in designing precise quality measures for reporting, introducing inconsistencies and unnecessary duplication of effort for both vendors and clients. One vendor described their wasted efforts in developing for stage 1:

> In stage 1, the changing regulations caught us by surprise, and we lost thousands of hours of programming. When the meaningful use matrix came out on June 14th, we started programming for that. Then when the interim final rule came out, we had to stop a lot of things and start others, particularly on threshold reporting. Then the final rule came out, and most of the revenue cycle elements were taken out, like insurance eligibility reporting. And then the test scripts came out, and things like CDC codes for smoking came out, we had to change our databases again. So that was thousands of hours of wasted work. We were constantly reacting to changing specifications.

Additionally, many noted that, because of a larger and more varied client base coming on-line in the hopes of attesting completion of stage 1, their testing processes had to be revamped to accommodate a wider range of potential system use settings and methods.

All vendors interviewed also noted that the timeline to release updated or newly created functions to help clients reach compliance with stage 1 of meaningful use had led to more difficulty than originally anticipated. While the increased demand was a boon to vendors in terms of revenue, working with a wide range of hospital clients with inconsistent levels of EHR adoption experience and capabilities was taxing on development staff. Attempting to meet their specific needs while primarily addressing the bulk of the stage 1 requirements was a significant challenge. One vendor noted that they had to make explicit trade-offs in this process:

> We have significant clients in the arena of behavioral health with different documentation requirements, both in having different standards and different patient care plans. Our plans for inpatient just aren't in the type of workflow they really want, but without that being in meaningful use we don't have the bandwidth to address that.

Vendors shared several other functions where they had additional development plans, but have had to ship products before all elements were completed. CPOE in particular was frequently mentioned in this regard, as were interfaces with medical devices. For CPOE, vendors noted that more precise abilities to dictate titrations at the point of order were highly requested by clients, but delayed because of limited development bandwidth. Vendors also pointed to device interfaces for technology such as inpatient infusion pumps as requiring significant programming effort to develop and test, but without inclusion in the meaningful use criteria have been delayed indefinitely.

While vendors anticipate that requirement dissemination for stages 3 and beyond will be more direct and consistent than they experienced for stage 1, several still expressed concerns as to the number of new functions and capabilities likely to be required over the time frame. "If you put fifty projects in stage 3," one vendor remarked, "we may only have the bandwidth to do thirty of those."

Several vendors focusing on the large-hospital market pointed to additional areas of interest which have been de-prioritized as both meaningful use and the transition to ICD-10 have dominated developer bandwidth. In particular, these vendors pointed to two areas where the business case for development was less evident, but for which they see significant need – long-term care (LTC) and shared-savings care models. With regards to long term care, several vendors mentioned the increasing interest among hospital systems in acquiring and building long term care facilities as an element which could contribute to demand for LTC-specific interfaces, but given the lack of incentive payments and current interest from financially-strapped long-term care facilities, development has been delayed. "There isn't a business case for it – right now, people just don't have the money for it," one large vendor specializing in hospital systems noted, "but there's a real need for it and right now we're struggling to assess how to do it."

Similarly, large vendors pointed to the IT needs of shared-savings models – long-awaited care models such as accountable-care organizations require several tools which are not currently available in typical EHR implementations and are not anticipated by the meaningful use incentive program. Elements such as cross-venue collaboration and provider collaboration, referral management and chronic patient-care management tools are on the long-term agenda for vendors, but are not viable in the short term, despite their benefits in supporting such care models.

Vendors broadly agreed that, because of significant client interest, mobile device access would be a greater development priority in the short-term were it not for the current meaningful use requirements. Several vendors pointed to mobile access as a differentiating factor which would draw attention, but suggested that robust security for mobile access would take significant development time that they were not yet prepared to allocate. "It's a 'wow' feature for a lot of doctors," one vendor noted. "Even if it's not included in meaningful use, it's the kind of thing we'd otherwise like to do because it gets attention and would make us stand out." In total, vendors suggested that the meaningful

use incentive program has succeeded in bringing desired functions to the forefront of development and implementation, but not without trade-offs in terms of other adoption and development priorities.

Discussion

Three key findings stem from this research. First, the meaningful use requirements can serve as either a floor or a ceiling, depending on the abilities of the facility implementing EHRs. For large hospitals, the requirements are a floor, above which further development and customization continues. For smaller hospitals, the requirements are a ceiling, which will be met but not exceeded as the requirements continue to escalate. Second, the increasing focus on meeting the requirements across both hospitals and vendors in the industry risks missing the forest of health care system change through the trees of meeting discrete requirements. Without further development on the technology needed for population health care and management of shared-savings models, the American health care system lacks the infrastructure for successful health reform. Third, while the meaningful use incentive program has accelerated the development and implementation of some functions, it has also slowed development of other important functions. Furthermore, some functions viewed as crucial to effective use of EHRs remain ineffective or underutilized, despite their inclusion in the requirements.

Large hospitals, and the vendors who stand to gain significantly from the incentive program, see broad positive effects resulting from the introduction of the meaningful use incentive program, and often remain ambitious in pursuing development and implementations above and beyond the meaningful use requirements. Their ability to leverage economies of scale and their access to the capabilities of larger implementation teams make further development and customizations feasible goals. Looking forward, it remains to be seen how ongoing maintenance and subscription costs will affect small facilities, particularly rural and critical-access facilities, after the conclusion of the incentive program. CIOs noted their frustration with the substantial ongoing costs of ownership, and will depend on operational savings that are yet to materialize to fund future costs of ownership.

Nevertheless, the positive effects attributed to the incentive program have come, in some instances, at the expense of development of tools used in other aspects of clinical practice and health care system change. In particular, tools to manage population health and support shared-savings care models are suffering from a lack of development, at the expense of both meaningful use requirements and the industry-wide transition to ICD-10 coding standards. The meaningful use program sees as its goal not just the adoption of EHR technology, but more importantly improvements in the quality and costs of effective health care. If promoting meaningful use of EHRs slows development of the tools necessary for broader health system change, policy makers should reevaluate the extent and focus of meaningful use requirements.

It may be a result of the unique incentives at work in the hospital industry, but the lack of a business case for development of interfaces with inpatient medical devices and resources for shared-savings models are both surprising and disappointing. Given their benefits in improving safety while decreasing the effort required in monitoring a patient, future development of effective interfaces between new and upcoming devices and existing EHR implementations would be a positive development. Similarly, CMS efforts to test and evaluate shared-savings models, in the form of accountable care organization pilot programs across the country, could see substantial benefit from the availability of IT aimed at meetings their unique needs. Elements such as referral management, cross-setting collaboration, and chronic care management could improve administration of shared-savings models. As it stands, investment in ongoing meaningful use certification and ICD-10 compatibility have, according to vendors, limited the development bandwidth available to improve offerings in this area. Given the extensive prior research and the contemporary statistics suggesting that the industry is likely to consolidate given the presence of federal incentives, the lack of development on these tools is troubling. If the industry is to see alternative care models succeed, population health management tools will be essential to effective implementation.

Despite these concerns, increased adoption coinciding with the beginning of incentive payments supports the findings from discussions which suggests that many hospitals with the capabilities were aggressive in bringing their existing EHR installations in line with the stage 1 requirements, or beginning the process of implementing comprehensive EHRs from scratch. The principal impact of the incentive program, therefore, was to accelerate the timeline to adoption and meaningful use for the majority of US hospitals – particularly in areas where the evidence of benefit was clear but clinical support was less than unwavering, such as with CPOE.

Vendors pointed to the principal change brought about by the incentive program as the creation of a sound business case for the development of interoperability interfaces, public health reporting tools, and consumer engagement interfaces – none of which were at the forefront of development roadmaps until their inclusion in meaningful use requirements. At the same time, vendors were also consistent in pointing to slowed development of mobile offerings, medical device interfaces, and hospital specialty customizations (e.g. specified interfaces for behavioral health, physical therapy, surgery, and other departments with unique requirements) as the trade-offs they made in pursuing meaningful use certification.

Policy Implications

Policy makers should be aware of the effects of the meaningful use incentive program in both prioritizing and de-prioritizing EHR function development and adoption, and take steps to ensure the requirements for subsequent stages of meaningful use do not crowd out development of the technology essential to health care system change. In particular, policy makers can pursue three key goals: first, direct assistance to small and rural facilities in meeting the meaningful use criteria over time, second, increased focus on building incentives for development and use of population health and shared savings model tools, and third, prioritization of underdeveloped features such as effective interoperability and tools for hospital specialties and subspecialties.

Policy makers should anticipate significant growing pains as hospitals adjust to the benefits and shortcomings of their particular IT installations. Many early adopters are beginning to discover that their initial IT implementations, whether an integrated single-vendor package or an amalgam of best-of-breed functions, do not perform in the ways they had hoped. For hospitals with limited resources, the challenge of attesting their compliance with subsequent stages of meaningful use in a limited amount of time makes changing vendors a difficult proposition. At the same time, failing to attest on time for subsequent stages will reduce incentive payments and make it more difficult to afford a more effective EHR solution. In particular, as more hospitals discover that interoperability and data exchange across functions and hospital units remains a significant hurdle to widespread effective use of EHRs, the number of CIOs looking for integrated single-vendor solutions is increasing. Similarly, as the trend of hospital consolidation continues across the industry, the need for reliably functioning interoperability interfaces will become even more critical. Hospitals will be pressuring their vendors for the capabilities to reliably share and transfer data across systems, and vendors will look to CMS for guidelines on standards. The recently announced delay of stage 3 requirements should help both hospitals and vendors as they adjust to the current state of development, and help mitigate concerns that changing vendors will preclude successfully attesting to subsequent stages of the meaningful use requirements.

In particular, requirements will place the largest burden on small and rural hospitals. Prior research on government incentives predicted a lag in adoption among these smaller consumers, and current experience in the EHR incentive program has borne this theory out. Targeted efforts on the part of CMS to assist small, rural, and critical-access hospitals with the unique challenges they face, not only with a lack of financial resources but also with a lack of organizational expertise, will be crucial to continued adoption among these providers. In some cases, the tools necessary for population health can be included in subsequent stages of the EHR incentive program, but this will not be universally true. Just as vendors and CIOs stated their disapproval of some of the capabilities required of them in stages 1 and

2, trying to shoehorn shared savings elements into development and require their use would require excessive diversion from the workflows at use in traditional care models.

Requirements in subsequent stages of the program will be competing for resources with internal EHR customization and expansion goals. For high-priority functions, policy makers should note that inclusion among the meaningful use requirements not only ensures the full support of hospital administration for successful implementation, but also serves as a powerful external signal to hospital staff and physicians that their participation is not solely about satisfying internal initiatives but also represents compliance with an evidence-based federal mandate.

Above all, policy makers should be aware that additional requirements have thus far led to explicit decisions on the part of both hospitals and vendors to deprioritize other development and implementation interests, and should make efforts to assess what features or functions are being de-prioritized when additional requirements are added to the incentive program.

According to discussions, interoperability would not have been a focus of vendor development efforts in the absence of the certification requirements, and a greater focus on interoperability standards and requirements in subsequent stages can help improve the flow of hospital within and between hospitals. Furthermore, CMS can look to key hospital subspecialties as areas where development may be worth targeting subsequent stages of the meaningful use criteria. In particular, behavioral health was discussed by both vendors and hospital CIOs as an area where additional development would be beneficial, but progress has slowed because other requirements have been more time-sensitive. Across the United States, however, improvements in behavioral health management are an immediate need. Customized interfaces for behavioral health practitioners would have substantial benefits, particularly given the importance of accurate, accessible, long-term data in successful mental health care.

The meaningful use incentive program has been successful in the goal of encouraging more providers to take on the challenge of implementing and using electronic health records. While the pace of adoption is slowly increasing, policy makers can look forward to stages 2 and 3 as opportunities to address developments which should be included in the incentive program with the awareness that inclusion will necessitate trade-offs by vendors and hospitals as they develop and implement the technology. Policy makers should prioritize those functions with the greatest benefits for quality of care and support facilities facing the greatest challenges in marshalling the personnel and resources to effectively manage meaningful use of electronic health records.

Limitations

This study has several limitations. Because it relies partially on qualitative interviews with a small subset of US hospitals, it is exploratory and not necessarily representative of all US acute-care hospitals. I attempted to capture potential differences by including hospitals from a range of settings, sizes, and other key characteristics. Regardless, the findings are most generalizable to facilities with characteristics most similar to those in the study. This study should not be viewed as an exhaustive assessment of how all US hospitals and HIT vendors have responded to the meaningful use incentive program, but rather it is an initial assessment of the effects of the incentive program on development and adoption meant to help inform future policy in this area.

The quantitative data used, from the AHA survey, also lead to several limitations. First, although response rates are high across each included year of the survey (averaging nearly 65 percent over the included four years), the results provided may not accurately reflect the full population of the nation's acute-care hospitals. Next, the AHA surveys do not ask specifically about the exact functions as described in the stage 1 final rule, but rather ask about these functions more generally. Jha et al. have specified a mapping of the AHA survey questionnaire to the stage 1 core meaningful use requirements, and I have adopted that mapping here. Finally, the fact that this is survey data leads to two further

limitations: responses come from hospital staff (most frequently a hospital CIO), not independent observers, and the survey only accounts for implementation of the functions, not the extent to which they are used (and the appropriateness of that use).

Appendix A: Vignette Wordings

Vignette 1:

A new drug is available for a serious, debilitating disease. It does not cure the disease, but it can provide relief from the symptoms. In another country, the national government decided to pay for this drug only for a limited number of patients because of the drug's high cost of $15,000 a year. The drug is reserved for those patients who are most likely to see significant health benefits. Some people have objected to the decision because they argue that other patients might also benefit from the drug.

If this decision to (pay for/provide) this drug only for a limited number of patients were made in the US, would you approve or disapprove of the decision?

Vignette 2:

In another country, two drugs are available to treat a debilitating condition in the elderly. One of the drugs costs about 100 times as much as the other. The more expensive one has been tested and shown to be effective for people with this condition. The less expensive one has not been tested in research studies for treating this illness. However, many physicians who specialize in the condition use the lower-cost drug because they believe it is safe and effective for their patients. The government in that country decided to provide only the less expensive drug even though it had not been tested for this illness.

If this decision only to (pay for/provide) the less expensive drug that had not been tested for this illness were made in the US, would you approve or disapprove of the decision?

Vignette 3:

In another country, the national government decided against providing a new drug for treating an advanced form of cancer. On average, the drug costs $35,000 per patient. The drug does not cure the

disease, but studies suggest that using the drug can add, on average, about six months to a patient's life. Some patients would gain only a short period, while others could gain a lot more time.

If this decision not to (pay for/provide) this drug were made in the US, would you approve or disapprove of the decision?

Vignette 4:

In another country, the national government decided against paying for the use of an imaging technology for diagnosing certain types of cancers. The technology is more expensive than alternative methods, costing over $2,000 per use. After conducting an evaluation, a government organization concluded that there was not enough scientific evidence to recommend using the technology for these other types of cancer. Other countries, however, actively use this technology for multiple types of cancer, because many doctors believe it provides the best most detailed view of these other types of tumors.

If this decision not to (pay for/provide) this technology to help diagnose these other types of cancers were made in the US, would you approve or disapprove of the decision?

Appendix B: Background on the role of public opinion in health policy

Assessing public opinion regarding cost effectiveness agencies and decisions requires a discussion of the political environment in which any health policy reforms will inevitably be brought up for debate. A review of the political science literature demonstrates that the American political system is currently highly polarized. With regards to health policy, polarization drives political debate, with public opinion on most health policy issues sharply divided along partisan lines. These factors have been critical to an understanding of the history of attempts at health care reform, which have been characterized by numerous failures, often brought about in part by a lack of broad public support for key proposals. That being said, there is reason to believe that specific cost effectiveness vignettes are unlikely to be judged solely along partisan lines, but may also be driven by a confluence of factors related to the state of the current health care system in America.

Polarized Politics in the United States

A wealth of research demonstrates that the United States political environment is highly polarized, with the extent of differences between the parties of the right and left increasing year over year for the last three decades[95–97]. McCarty, Poole, and Rosenthal trace this modern period of increasing polarization back to 1977, and see a simultaneous wave of increased immigration introducing more non-citizens[98]. They posit that these non-citizens, disproportionately lower-income, are unable to exert political pressure in favor of policies designed to reduce inequality. At the same time, Republicans have moved further to the right, with greater opposition to redistributive policies in response to an electorate better able to generate political and voting pressure in opposition to those policies. Carmines and Stimson point out that racial issues became a matter of increased polarization beginning in the 1960s with the increasing struggle for Civil Rights[99]. Others demonstrate that the ideological divide extended even further, to broader cultural issues, in the 1980s and 1990s[100,101]. These partisan divides

have extended across all the major policy dimensions in American politics – including health care – in a process Layman et al. refer to as "conflict extension"[102].

This polarization and ideological cohesion among Democrats and Republicans has made finding common ground exceedingly difficult for a host of important policy outcomes, health care among them. In fact, health care serves as a clear illustration of the creeping scope of polarization. In many ways, the Democrats signature health legislation of the 21st century, the Affordable Care Act, is a model of sound Republican ideas from the 20th century. The act mirrors many of the proposal made by President Nixon in his ill-fated attempt to engender the support of the American people for health reform, and incorporates a newly-controversial Individual Mandate, which until the turn of the century was considered a solidly Republican concept[103]. Yet, as polarization has increased, the ability for Democrats to find ideological allies in the Republican Party for ideas which came from the past of that same Republican Party diminished to virtually zero. This aligns with the research, where McCarty et al. find that in Congress, representative show less alignment in their voting records than in decades past, with fewer moderates elected to office in either party[98]. Layman and Carsey point out that the extent of such polarization extends beyond the halls of congress to party elites, think tanks, and the electorate at large[104].

One area where both parties have found agreement is with regards to trust in government. Separate from declines in group cohesion/social capital and seemingly unrelated to trends in economic performance, public opinion on government's likelihood to "do the right thing" all or some of the time has declined precipitously over the past 40 years, approaching 10% in recent years[105–107]. With this decline comes an increasing hesitance to expand the role of government and decreasing belief in the ability of government to serve as a positive force in solving social problems. Nye et al. point to this decreasing trust as a hindrance to functional government, with declining trust putting the legitimacy of

the government on matters of critical national importance, such as economic performance and health policy, into serious question[107].

The Role of Public Opinion in Policy Outcomes

Prior research has consistently identified a link between public opinion and policy outcomes, with public opinion serving not just as a predictor of eventual outcomes, but having a causal effect on eventual outcomes[108,109]. In health policy issues, as well as many others, research suggests that individuals tend to make decisions in ways that more closely reflect their political ideology rather than what would be assumed to be their self-interest given socioeconomic status[110–112]. For example, Republicans regardless of socioeconomic status are more likely to oppose increased government spending, including means-tested spending on lower-income individuals and families. Democrats, regardless of socioeconomic status, are more likely to support increased access to health care and increased spending on children[113,114]

Self-Interest and Public Opinion

Research in the political science literature as to the role of self interest in political behavior remains inconclusive, with the topic still a matter of active debate. The work of Andrea Campbell illustrates that senior citizens have mobilized aggressively with regards to Medicare and Social Security policy, in direct alignment with their self-interest[115–117]. Similarly, Braman and Ensley demonstrate that self-interest is highly predictive of response to regulation of managed care organizations, a clear example of the role of self-interest at play in health care reform and health policy issues[118]. Others have found that the relationship between self-interest and political behavior is less clear. For example, Rosenstone et al. find that personal finances have no measurable effect on political attitudes. Economic concerns may affect political decision-making more broadly, as research suggests that support for government health care spending is tied to the strength of the national economy[114]. Other researchers

have demonstrated that group interests weigh more heavily than individual interests in political decision-making[119].

Health Care Reform and Public Opinion

Prior research in public opinion on health care has led to two key findings. First, there exists substantial continuing concern among the general public about problems with the health care system – in particular, with high and increasing costs. Second, over time, public opinion most often shifts to oppose the specifics of any policy designed to address these problems, most often driven by individuals' personal satisfaction with the provision of their own health care[120].

Prior efforts at health care reform have often followed very similar patterns, particularly when efforts are centered around expanding access to insurance coverage. Blendon et al. have identified the pattern whereby public support begins at a high level when discussions of major health reforms begin, but declines steadily as more details of the proposed reform are made known and are criticized by opposition[121,122]. Existing research on public opinion data suggests this reflects a general interest in comprehensive health reform and universal health insurance, but extensive disagreement on the particular policies to be enacted in support of these goals. Hibbing and Theiss-Morse also suggest that the processes of policymaking are also contributing to shaping Americans' views of proposals[123]. This is particularly relevant to health policy, where special interest groups operate in competition for preferred outcomes, which is particularly disliked by the American public. In total, the research illustrates that it is extremely difficult to maintain high public support for health policies in the current political environment.

Sociodemographics and Public Opinion on Health Policy Issues

A review of the literature also reveals clear sociodemographic divisions in public opinion on health policy issues[124,125]. Schlesinger and Lee have studied the relationship between sociodemographics

and support for a government role in health care, and found sharp differences by a variety of sociodemographic variables, including income, education, age, race, gender, and region. They found that higher-income respondents were less likely to support a government role in health care provision, as were better educated respondents and older respondents[125]. They found whites to be less supportive than blacks, but found no significant differences between men and women. Schlesinger and Lee tie these results to self-interest, arguing that they support the hypothesis that those with less self-interest in a broader government role in the provision of health care were less likely to support such an expansion.

Cost Effectiveness Research and Public Opinion

Prior research shows from Blendon et al. shows that, while there is substantial public support for the use of *comparative* effectiveness research, the public distinguishes between comparative- and cost-effectiveness research and does not support the latter[126]. In this paper, we seek to identify *why* the majority of Americans hold negative views about cost-effectiveness research, and attempt to draw out distinctions among population groups to identify where opposition is strongest.

In looking at distinctions within support for comparative effectiveness research, Gerber et al. suggest that the American public maintains broad support for using comparative effectiveness research to provide information and inform treatment decisions, but substantially less support for using research to allocate government resources or mandate treatment decisions[127]. Their research finds that two thirds of Americans support the idea of making research available for health consumers, and roughly half support its use in determining whether public and private insurers should cover/reimburse new treatments. Other research by Carman et al. suggests that the American public is skeptical of any medical research distinct from the advice they receive from their doctors[128].

These findings would suggest that support for or opposition to integration of cost effectiveness research in coverage decisions would in part be driven by self-interest, in terms of exposure to the health care system in the form of serious illness. Specific vignettes could see less of a partisan role to patterns of support and opposition, since the present debate in the United States has yet to extend to the merits of particular decisions. Instead, exposure to and reliance on the health care system may well be a more powerful predictor of public opinion on specific uses of CER.

Appendix C: Item wordings of variables

Outcome Variable - Support for a Government CER Agency

> Do you favor or oppose the U.S. having a government decision-making body that recommends whether government programs should pay for (prescription drugs/ medical or surgical treatments) if they think they cost too much?

Note: Each version ("prescription drugs" and "medical or surgical treatments" asked of half-sample

Independent Variables

Satisfaction with Health Care System

> In general, would you say you are very satisfied, fairly satisfied, neither satisfied nor dissatisfied, fairly dissatisfied, or very dissatisfied with the way health care runs in the U.S.?

Experience with Serious Illness

> Have you, or any member of your family who lives with you, had a serious illness, chronic condition, injury, or disability that has required extensive medical care in the last 12 months?

Trust in Government to Make Health Care Decisions

> Do you tend to trust or not to trust the federal government to make the right health care decisions?

Education

> What is the highest grade of school or year of college you have completed?

Income

> What was the total combined income, before taxes, for all members of your household last year? You can stop me when I get to the right category. Was it …?

1 Less than high school graduate
2 High school graduate
3 Some college
4 Graduated college
5 Graduate school or more
6 Technical school/Other
6 $30,000 but less than $35,000
7 $35,000 but less than $40,000
8 $40,000 but less than $50,000
9 $50,000 but less than $75,000
10 $75,000 but less than $100,000
11 $100,000 and over

Party Identification

Generally speaking, do you usually think of yourself as: (a Democrat), (a Republican), an independent or what?

Note: Order of items in parentheses was presented at random.

Race/Ethnicity

What is your race? Do you consider yourself to be white, black or African American, Asian, Native American, or some other race?

Are you, yourself of Hispanic or Latino origin or descent such as Mexican, Puerto Rican, Cuban, Dominican, Central or South American, Caribbean or some other Latin American background?

Age

Could you please tell me if you are …?

1 18-29
2 30-49
3 50-64
4 65+

Appendix D: Demographic Profile of Weighted Sample, n=1007 respondents

	Sample %	95% CI
Gender		
Male	48.30%	[44.4-52.2]
Female	51.70%	[47.8-55.6]
Race/Ethnicity		
White (Non-Hispanic)	72.80%	[68.8-76.5]
Black (Non-Hispanic)	12.20%	[9.6-15.3]
Hispanic	15.00%	[12.0-18.6]
Age		
Age 18-29	20.90%	[17.4-24.9]
Age 30-49	35.70%	[31.9-39.6]
Age 50-64	25.80%	[22.8-29.0]
Age 65+	17.60%	[15.4-20.1]
Party Identification		
Democrat	34.10%	[30.3-38.2]
Republican	24.90%	[21.5-28.6]
Independent	41.00%	[36.9-45.3]
Total Household Income		
Less than $10,000	7.30%	[5.1-10.2]
$10,000-$15,000	6.00%	[4.1-8.6]
$15,000-$20,000	7.50%	[5.5-10.2]
$20,000-$25,000	4.70%	[3.1-7.0]
$25,000-$30,000	5.70%	[4.0-8.3]
$30,000-$35,000	4.20%	[2.7-6.4]
$35,000-$40,000	5.80%	[3.9-8.5]
$40,000-$50,000	7.40%	[5.5-9.9]
$50,000-$75,000	17.80%	[14.7-21.3]
$75,000-$100,000	14.40%	[11.7-17.6]
$100,000 and over	19.20%	[16.3-22.4]
Highest Level of Education Completed		
Less Than High School	11.70%	[8.9-15.2]
High School Graduate	28.30%	[24.8-32.1]
Technical School	2.70%	[1.7-4.3]
Some College	28.80%	[25.3-32.5]
Graduated College	16.10%	[13.8-18.7]
Graduate School	12.40%	[10.5-14.6]

Appendix E: Intermediate Models and Alternative Specifications

Table E.1: Alternative specifications
Multilevel longitudinal poisson regression results
Standard errors clustered at the state level

	Model E.1.1	**Model E.1.2**
Urban Location	1.328*** (0.0195)	1.325*** (0.0195)
Teaching Status	1.183*** (0.0152)	1.185*** (0.0152)
For-Profit Status	0.868*** (0.0154)	0.864*** (0.0153)
AMI % betablocker	1.004+ (0.00213)	1.003 (0.00215)
Year		
2008	1 (.)	1 (.)
2009	0.992 (0.0137)	0.991 (0.0137)
2010	1.417*** (0.0192)	1.415*** (0.0191)
2011	1.545*** (0.0211)	1.544*** (0.0211)
Hospital Total Margins (Decreasing)	0.985*** (0.00183)	0.964*** (0.00489)
State Legislation HIT Financing	1.011 (0.0122)	0.975 (0.0166)
Interaction: Total Margins * State Legislation		1.008** (0.00256)
Hospital System Membership	1.021* (0.0105)	1.019+ (0.0105)
Hospital Size		
Small	1 (.)	1 (.)
Medium	1.163*** (0.0149)	1.166*** (0.0149)
Large	1.222*** (0.0225)	1.224*** (0.0226)
0-3% Margin Hospitals		
Interaction: Small Negative Margin * State HIT Financing		
Observations	11075	11094
AIC	54661.9	54764.3
BIC	54764.3	54874
Exponentiated coefficients; Standard errors in parentheses		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Table E.2: Multilevel longitudinal poisson regression results
Standard errors clustered at the hospital level

	Model E.2.1	Model E.2.2	Model E.2.3
Urban Location	1.318*** (0.0310)	1.364*** (0.0354)	1.360*** (0.0353)
Teaching Status	1.258*** (0.0299)	1.208*** (0.0313)	1.209*** (0.0314)
For-Profit Status	0.750*** (0.0195)	0.841*** (0.0263)	0.836*** (0.0262)
AMI % betablocker	1.004** (0.00138)	1.002 (0.00151)	1.002 (0.00152)
Year			
2008	1 (.)	1 (.)	1 (.)
2009	0.973* (0.0124)	0.991 (0.0137)	0.990 (0.0137)
2010	1.334*** (0.0161)	1.396*** (0.0192)	1.395*** (0.0192)
2011	1.510*** (0.0194)	1.533*** (0.0215)	1.532*** (0.0214)
Hospital Total Margins (Decreasing)		0.979*** (0.00334)	0.955*** (0.00890)
State Legislation HIT Financing	1.002 (0.00670)	1.012+ (0.00715)	0.981 (0.0234)
Interaction: Total Margins * State Legislation			1.006 (0.00476)
Hospital System Membership	1.127*** (0.0206)	1.063** (0.0212)	1.062** (0.0212)
Hospital Size			
Small	1 (.)	1 (.)	1 (.)
Medium	1.229*** (0.0254)	1.196*** (0.0285)	1.200*** (0.0286)
Large	1.243*** (0.0417)	1.223*** (0.0445)	1.226*** (0.0447)
Dummy: Small Negative Margin Hospitals	0.885** (0.0408)		
Interaction: Small Negative Margin * State HIT Financing	1.037 (0.0236)		
Observations	13869	11075	11094
AIC	65162.9	52184.4	52280.3
BIC	65275.9	52286.8	52390
Exponentiated coefficients; Standard errors in parentheses			
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001			

Table E.3: Multilevel longitudinal poisson regression results
Standard errors clustered at the state level

	Model E.3.1	**Model E.3.2**
Urban Location	1.420*** (0.0186)	1.417*** (0.0185)
Teaching Status	1.260*** (0.0144)	1.255*** (0.0143)
For-Profit Status	0.874*** (0.0152)	0.889*** (0.0157)
AMI % betablocker	1.003 (0.00209)	1.003 (0.00207)
Year		
2008	1 (.)	1 (.)
2009	0.999 (0.0136)	0.999 (0.0136)
2010	1.426*** (0.0190)	1.424*** (0.0190)
2011	1.558*** (0.0210)	1.558*** (0.0209)
Hospital Total Margins (decreasing)	0.970*** (0.00337)	
Hospital Total Margins – Categorical		
Margin: Greater than 20%		0.940 (0.0355)
Margin: 15% - 20%		1.077** (0.0292)
Margin: 10% - 15%		1.019 (0.0180)
Margin: 5% - 10%		1.045*** (0.0129)
Margin: 0% - 5%		1 (.)
Margin: 0% - -5%		0.929*** (0.0139)
Margin: -5% - -10%		0.885*** (0.0193)
Margin: -10% - -15%		0.844*** (0.0305)
Margin: Less than -15%		0.925+ (0.0375)
Observations	11407	11407
AIC	56509.7	56470.3
BIC	56583.1	56595.1
Exponentiated coefficients; Standard errors in parentheses		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Table E.4: Multilevel longitudinal poisson regression results
Standard errors clustered at the hospital level

	Model E.4.1	**Model E.4.2**
Urban Location	1.491*** (0.0338)	1.489*** (0.0336)
Teaching Status	1.287*** (0.0301)	1.281*** (0.0300)
For-Profit Status	0.862*** (0.0264)	0.882*** (0.0276)
AMI % betablocker	1.003* (0.00142)	1.003* (0.00142)
Year		
2008	1 (.)	1 (.)
2009	0.998 (0.0136)	0.998 (0.0136)
2010	1.404*** (0.0190)	1.403*** (0.0190)
2011	1.545*** (0.0213)	1.544*** (0.0213)
Hospital Total Margins (decreasing)	0.959*** (0.00625)	
Hospital Total Margins – Categorical		
Margin: Greater than 20%		0.926 (0.0650)
Margin: 15% - 20%		1.093+ (0.0586)
Margin: 10% - 15%		1.033 (0.0358)
Margin: 5% - 10%		1.059* (0.0260)
Margin: 0% - 5%		1 (.)
Margin: 0% - -5%		0.897*** (0.0257)
Margin: -5% - -10%		0.852*** (0.0347)
Margin: -10% - -15%		0.810** (0.0523)
Margin: Less than -15%		0.876+ (0.0646)
Observations	11407	11407
AIC	53869.6	53859.2
BIC	53943	53984
Exponentiated coefficients; Standard errors in parentheses		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Table E.5: Multilevel longitudinal poisson regression results
Standard errors clustered at the state level

	Model E.5.1	Model E.5.2	Model E.5.3	Model E.5.4	Model E.5.5
Urban Location	1.432*** (0.0192)	1.436*** (0.0187)	1.433*** (0.0191)	1.420*** (0.0186)	1.420*** (0.0186)
Teaching Status	1.259*** (0.0144)	1.271*** (0.0144)	1.260*** (0.0144)	1.262*** (0.0143)	1.262*** (0.0144)
For-Profit Status	0.876*** (0.0151)	0.879*** (0.0149)	0.871*** (0.0148)	0.877*** (0.0151)	0.877*** (0.0151)
Total Margin (increasing)	1.721*** (0.114)	1.005* (0.00264)	1.003 (0.00215)	1.729*** (0.114)	1.728*** (0.114)
Year					
2008	1 (.)	1 (.)	1 (.)	1 (.)	1 (.)
2009	0.993 (0.0137)	0.996 (0.0135)	0.989 (0.0136)	0.999 (0.0136)	0.999 (0.0136)
2010	1.419*** (0.0191)	1.424*** (0.0188)	1.416*** (0.0190)	1.427*** (0.0190)	1.427*** (0.0190)
2011	1.548*** (0.0211)	1.556*** (0.0207)	1.544*** (0.0209)	1.558*** (0.0209)	1.558*** (0.0209)
State Legislation Categories:					
HIT Financing	1.014 (0.0121)				
E-prescribing		1.069+ (0.0410)			
Health Information Exchange			1.060 (0.0440)		
Data Security				0.965 (0.0512)	
Comprehensive					1.015 (0.0510)
Observations	11127	11431	11431	11431	11431
AIC	55114.5	56630.2	56631.1	56632.7	56633
BIC	55187.7	56703.6	56704.6	56706.1	56706.5
Exponentiated coefficients; Standard errors in parentheses					
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001					

Table E.6: Multilevel longitudinal poisson regression results
Standard errors clustered at the hospital level

	Model E.6.1	Model E.6.2	Model E.6.3	Model E.6.4	Model E.6.5
Urban Location	1.513*** (0.0351)	1.489*** (0.0337)	1.492*** (0.0338)	1.498*** (0.0340)	1.490*** (0.0337)
Teaching Status	1.291*** (0.0304)	1.296*** (0.0302)	1.297*** (0.0302)	1.290*** (0.0300)	1.294*** (0.0301)
For-Profit Status	0.855*** (0.0257)	0.848*** (0.0255)	0.855*** (0.0256)	0.855*** (0.0256)	0.853*** (0.0256)
Total Margin (increasing)	2.153*** (0.269)	2.149*** (0.266)	2.161*** (0.268)	2.196*** (0.272)	2.176*** (0.270)
Year					
2008	1 (.)	1 (.)	1 (.)	1 (.)	1 (.)
2009	0.991 (0.0137)	0.998 (0.0136)	0.998 (0.0136)	0.998 (0.0136)	0.998 (0.0136)
2010	1.396*** (0.0192)	1.404*** (0.0190)	1.404*** (0.0190)	1.404*** (0.0190)	1.404*** (0.0190)
2011	1.533*** (0.0214)	1.545*** (0.0213)	1.545*** (0.0213)	1.544*** (0.0213)	1.545*** (0.0213)
State Legislation Categories:					
HIT Financing	1.013+ (0.00693)				
E-prescribing		1.039+ (0.0230)			
Health Information Exchange			0.963+ (0.0204)		
Data Security				0.920** (0.0262)	
Comprehensive					0.985 (0.0260)
Observations	11127	11431	11431	11431	11431
AIC	52503.4	53982.1	53981.8	53976.4	53984.7
BIC	52576.6	54055.5	54055.2	54049.8	54058.1
Exponentiated coefficients; Standard errors in parentheses					
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001					

Table E.7: Multilevel longitudinal poisson regression results
Standard errors clustered at the state level

	Model E.7.1	Model E.7.2	Model E.7.3
Urban Location	1.422*** (0.0186)	1.431*** (0.0192)	1.431*** (0.0192)
Teaching Status	1.260*** (0.0144)	1.259*** (0.0144)	1.256*** (0.0145)
For-Profit Status	0.875*** (0.0152)	0.876*** (0.0151)	0.871*** (0.0151)
Total Margin (increasing)	1.730*** (0.114)	1.719*** (0.114)	
AMI % Betablocker	1.004 (0.00256)		1.002 (0.00214)
Year			
2008	1 (.)	1 (.)	1 (.)
2009	0.999 (0.0136)	0.993 (0.0137)	0.992 (0.0137)
2010	1.426*** (0.0190)	1.419*** (0.0191)	1.418*** (0.0192)
2011	1.558*** (0.0210)	1.548*** (0.0211)	1.549*** (0.0211)
Total Margin (decreasing)			0.958*** (0.00481)
Market Concentration	0.955 (0.0395)		
State Ideology	1.000 (0.00218)		
State HIT Financing			0.967+ (0.0164)
Financing Legislation Categories - Breakdown			
No Financing		1 (.)	
Limited		1.082 (0.0531)	
Moderate		1.059 (0.0772)	
Comprehensive		1.041 (0.0368)	
Interaction: Total Margins * State HIT Financing			1.009*** (0.00254)
Observations	11401	11127	11309
AIC	56493.8	55116.6	55987.7
BIC	56581.9	55204.4	56075.7
Exponentiated coefficients; Standard errors in parentheses			
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001			

Table E.8: Multilevel longitudinal poisson regression results
Standard errors clustered at the hospital level

	Model E.8.1	Model E.8.2	Model E.8.3
Urban Location	1.508*** (0.0352)	1.505*** (0.0350)	1.512*** (0.0351)
Teaching Status	1.291*** (0.0303)	1.293*** (0.0304)	1.287*** (0.0305)
For-Profit Status	0.858*** (0.0263)	0.855*** (0.0259)	0.857*** (0.0263)
Total Margin (increasing)	2.075*** (0.259)	2.107*** (0.263)	
AMI % Betablocker	1.005** (0.00174)		1.001 (0.00152)
Year			
2008	1 (.)	1 (.)	1 (.)
2009	0.998 (0.0136)	0.991 (0.0137)	0.991 (0.0137)
2010	1.404*** (0.0190)	1.397*** (0.0192)	1.396*** (0.0192)
2011	1.545*** (0.0213)	1.533*** (0.0214)	1.534*** (0.0214)
Total Margin (decreasing)			0.948*** (0.00885)
Market Concentration	1.099 (0.0821)		
State Ideology	1.003+ (0.00146)		
State HIT Financing			0.969 (0.0232)
Financing Legislation Categories - Breakdown			
No Financing		1 (.)	
Limited		1.106** (0.0360)	
Moderate		1.104* (0.0509)	
Comprehensive		1.042* (0.0215)	
Interaction: Total Margins * State HIT Financing			1.009+ (0.00479)
Observations	11401	11127	11309
AIC	53848	52497.6	55987.7
BIC	53936.1	52585.4	56075.7

Exponentiated coefficients; Standard errors in parentheses

+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001

Table E.9: Multilevel longitudinal poisson regression results
Standard errors clustered at the state level

	Model E.9.1	Model E.9.2
Urban Location	1.413*** (0.0186)	1.318*** (0.0189)
Teaching Status	1.257*** (0.0144)	1.187*** (0.0151)
For-Profit Status	0.865*** (0.0153)	0.841*** (0.0160)
Total Margin	1.711*** (0.113)	1.625*** (0.108)
AMI % betablocker	1.004+ (0.00208)	1.004* (0.00212)
Year		
2008	1 (.)	1 (.)
2009	0.999 (0.0136)	0.998 (0.0136)
2010	1.427*** (0.0190)	1.424*** (0.0190)
2011	1.560*** (0.0210)	1.554*** (0.0209)
Hospital Size		
Small		1 (.)
Medium		1.164*** (0.0147)
Large		1.228*** (0.0224)
Hospital System Membership	1.034*** (0.0104)	
Hospital Sys Size		
Not in Sys		1 (.)
Small		0.988 (0.0149)
Medium		1.013 (0.0123)
Large		1.076*** (0.0173)
Observations	11401	11398
AIC	56482.1	56273.7
BIC	56562.9	56383.8
Exponentiated coefficients; Standard errors in parentheses		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Table E.10: Multilevel longitudinal poisson regression results
Standard errors clustered at the hospital level

	Model E.10.1	Model E.10.1
Urban Location	1.474*** (0.0337)	1.346*** (0.0341)
Teaching Status	1.280*** (0.0300)	1.211*** (0.0311)
For-Profit Status	0.841*** (0.0263)	0.813*** (0.0274)
Total Margin	2.093*** (0.260)	2.004*** (0.248)
AMI % betablocker	1.003* (0.00142)	1.004** (0.00141)
Year		
2008	1 (.)	1 (.)
2009	0.998 (0.0136)	0.997 (0.0136)
2010	1.405*** (0.0191)	1.403*** (0.0190)
2011	1.546*** (0.0213)	1.543*** (0.0213)
Hospital Size		
Small		1 (.)
Medium		1.193*** (0.0280)
Large		1.225*** (0.0441)
Hospital System Membership	1.080*** (0.0212)	
Hospital Sys Size		
Not in Sys		1 (.)
Small		1.010 (0.0298)
Medium		1.062** (0.0247)
Large		1.129*** (0.0346)
Observations	11401	11398
AIC	53836.6	53754.2
BIC	53917.4	53864.3
Exponentiated coefficients; Standard errors in parentheses		
+ p<0.10, * p<0.05, ** p<0.01, *** p<0.001		

Appendix F: Outcome measure and independent variable specifications

Outcome Measures

Number of Core Meaningful Use Functions Adopted (out of 8) – 2008-2011

Functions Measured
Computerized Provider Order-Entry
Drug-drug and drug-allergy interaction checks
Record demographics
Maintain up-to-date problem list of current and active diagnoses
Maintain active medication list
Provide patients with an electronic copy of their discharge instructions at time of discharge, upon request
Implement one clinical decision support rule
Report hospital clinical quality measures to CMS or states

Number of Core Meaningful Use Functions Adopted (out of 12) – 2010 and 2011 only

Functions Measured
All listed above, plus:
Record and chart changes in vital signs
Record smoking status for patients 13 years or older
Maintain active medication allergy list
Provide patients with an electronic copy of their health information, upon request

Independent Variables

The indicator independent variables in my analyses are as follows:

Competition Among Hospitals

Hospital Competition is measured by calculating the Herfindahl-Hirschman Index (HHI) for a given hospital system within each Hospital Referral Region (HRR). Hospitals not a part of any system are counted as their own system. Market share is calculated as the percentage of total beds for each hospital system within each hospital referral region. Based on the calculation, a low value (below 0.01) indicates a competitive market with no dominant hospitals/systems, while a high value (above 0.25) indicates a highly concentrated market with a small number of dominant hospitals/systems[129].

Hospital Total Margins (2007)

The variable is measured from positive to negative, with higher numbers representing lower (more negative) margins. Continuous and categorical versions of various thresholds were tested, and a categorical version with 5% margin increments is used here:

Hospital Margin Categories
Greater than 20%
15% - 20%
10% - 15%
5% - 10%
0% - 5%
0% - -5%
-5% - -10%
-10% - -15%
Less than -15%

Extreme outliers were removed from the analysis, and a dummy variable representing hospitals within 3% of profitability (hospitals from 0% total margin to -3% total margin) is evaluated to evaluate the effects of some levers on hospitals most likely to benefit from incremental financing.

Propensity to technological adoption in health care

A measure of the percentage of patients in each state receiving a beta blocker within 24 hours of a heart attack is used here, with data provided by Skinner and Staiger from 2000. As this represents a best practice in the treatment of acute MI, the variable is a proxy for the adoption of technological advances in health care.

Hospital Characteristics

Variable	Coding
Urban Environment	**1 = Urban; 0 = Rural**
Profit Status	**1 = For-Profit; 0 = Non-Profit**
Teaching Status	**1 = Teaching; 0 = Non-Teaching**

These three variables are derived from the annual AHA survey. When responses changed over the duration of the survey, the earliest year of response (2008, 2009, 2010) is used.

State Legislation - Financing

State legislation for health IT financing is coded as follows:

Category	Definition
1 (Limited Amount)	(< $1 million) allocated to acute-care hospitals
2 (Moderate Amount)	($1 million - $5 million)
3 (Comprehensive Funding)	(>$5 million)

Hospital Size

Hospital sizes are adopted from standard AHA measurements, which define the following categories:

Category	Definition
Small	99 or fewer beds
Medium	100-399 beds
Large	400 or more beds

Hospital System Size & Membership

Hospital system membership is a binary variable coded as 1 = system member, 0 = non-member.

Hospital system sizes are defined as follows:

Category	Definition
Small	999 or fewer beds
Medium	1000-6000 beds
Large	6001 or more beds

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